BLM LIBRARY
88009469

DRAFT

ENVIRONMENTAL STATEMENT

PROPOSED PLAN OF MINING AND RECLAMATION

BELLE AYR SOUTH MINE
AMAX COAL COMPANY
COAL LEASE W-0317682
CAMPBELL COUNTY, WYOMING

DES 75-14

OIL [illegible]
CEN[illegible]

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

V. E. McKelvey
Director

88009469

TD
195
C58
B44
1975

SUMMARY

(X) Draft ( ) Final Environmental Statement
Department of the Interior, U.S. Geological Survey

BLM Library
D-553A, Building 50
Denver Federal Center
P. O. Box 25047
Denver, CO 80225-0047

1. Type of Action:

(X) Administrative ( ) Legislative

2. Description of Action:

Approval of strip mining and reclamation plan, Belle Ayr South Mine, Amax Coal Company, Campbell County, Wyoming. Plan proposes expansion of the existing operation from 3.1 million to 15 million tons per year. Describes mining operations for a period of 25 years encompassing a total of about 3,018 acres of both Federal and private coal land. The land surface is privately owned. The coal is committed to electric power generation in Colorado, Texas, Kansas, and Iowa.

3. Summary of Environmental Impacts:

A. Land surface, vegetation, and the coal bed aquifers will be destroyed in the area mined.
B. Wildlife and habitats will be disrupted until disturbed areas are revegetated and large-scale human intrusions are terminated.
C. Ground and surface water quantity and quality, livestock grazing, scenic views and open space qualities will be degraded and restricted until revegetation is completed.
D. Dust and noise will be locally increased until revegetation is successful.
E. Employment in Campbell County will be increased.
F. Livestock and wildlife forage will be reduced until revegetation is successful.
G. There is a possibility that even with successful revegetation, there will be a reduction in productivity of the disturbed land, and
H. Tax and royalty income for Wyoming and Campbell County will be increased.

4. Alternatives Considered:

A. Reject mining plan.
B. Approve mining plan after modification.

5. Comments Have Been Requested From: (See Summary Attachment I).

6. Date Made Available to CEQ and Public: MAR 24 1975

SUMMARY ATTACHMENT I

Comments Have Been Requested From the Following:

- Environmental Protection Agency
- United States Department of the Interior
  - Bureau of Indian Affairs
  - Bureau of Land Management
  - Bureau of Mines
  - Bureau of Outdoor Recreation
  - Bureau of Reclamation
  - Fish and Wildlife Service
  - National Park Service
  - Office of Coal Research
- United States Department of Agriculture
  - Forest Service
  - Soil Conservation Service
- Federal Power Commission
- Federal Energy Agency
- United States Department of Health, Education and Welfare
- Interstate Commerce Commission
- Department of Transportation
- State of Wyoming
  - Governors Clearing House
  - State Historic Preservation Officer
- Board of County Commissioners of
  - Campbell County
  - Converse County

TABLE OF CONTENTS

Page

Preface 1

I. Description of Proposed Action 4

Background and History 4
Purpose of Proposed Project 8
Specific Site Location 9
Stages of Implementation 10

II. Description of the Existing Environment 26

Climate 26
Air Quality 30
Topography 31
Soils 35
Mineral Resources 44
Water Resources 57
Vegetation 69
Archaeological and Paleontological Values 74
Historical Values 76
Aesthetics 77
Wildlife and Fish 79
Recreation 84
Agriculture 85
Transportation Networks 88
Socio-Economic Conditions 89

III. Probable Impact of Proposed Action 90

Air Quality 90
Topography 94
Soils 95
Mineral Resources 98
Water Resources 99
Vegetation 106
Archaeological and Paleontological Values 108
Historical Values 109
Aesthetics 110
Wildlife and Fish 112
Recreation 114
Agriculture 115
Transportation Networks 117
Socio-Economic Conditions 118

Page

IV. Mitigating Measures 120

General 120
Supervisory Responsibility of the Geological Survey . . . 121
Air Quality 125
Topography 127
Soils 131
Water Resources 134
Vegetation 136
Archaeological and Paleontological Values 138
Historical Values 140
Aesthetics 141
Wildlife and Fish 142
Recreation 143
Agriculture 144
Transportation Networks 145

V. Probable Adverse Environmental Effects Which Cannot Be Avoided 146

Air Quality 146
Topography 147
Soils 148
Mineral Resources 149
Water Resources 150
Vegetation 151
Archaeological and Paleontological Values 152
Aesthetics 153
Wildlife and Fish 154
Recreation 155
Agriculture 156
Transportation Networks 157
Socio-Economic Conditions 158

VI. The Relationship Between Local Short Term Uses of Man's Environment and the Maintenance and Enhancement of Long Term Productivity 159

VII. Irreversible and Irretrievable Commitments of Resources . 162

VIII. Alternatives to the Proposed Action 165

Reject Mining Plan 165
Approve the Mining Plan After Modification 167

Page

IX. Consultation and Coordination With Others 172

Development of Statement 172
Review of Statement 173

GLOSSARY 174

SELECTED BIBLIOGRAPHY 183

APPENDICES

A. Copy of Federal Coal Lease, Wyoming 0317682 . . . . . . A-1

B. Notice of Public Availability of Mining and Reclamation Plan B-1

C. Preliminary Dust Survey and Air Quality Standards C-1

D. Summary Data from Meterological Station at the Belle Ayr South Mine Site D-1

E. Overburden Trace Element Analysis Data E-1

F. Selected Water Data F-1

G. Archaeological Survey G-1

H. Wildlife Survey Data H-1

I. Selected Regional Socio-Economic Data I-1

FIGURES

Page

Figure 1 Location of Belle Ayr Coal Mine - Amax Coal Company 5

2 Property Map - Amax Coal Company - Belle Ayr South Mine 6

3 Area to be Mined Annually - Belle Ayr South Mine . 11

4 Isometric View of Proposed Mining with Bucketwheel Excavator-Conveyor Belt System 16

5 Mine Plant and Surface Facilities Layout - Belle Ayr South Mine 22

6 Meterological Monitoring Station Location Map - Belle Ayr South Mine 28

7 Wind Rose - Belle Ayr South Mine 29

8 Topography of the Amax Coal Company Mine Area - Belle Ayr South Mine 32

9 Topography of Eastern Part of Lease - Belle Ayr South Mine 33

10 Topography of Western Part of Lease - Belle Ayr South Mine 34

11 General Soils Map - Belle Ayr South Mine 36

12 Overburden Thickness - Belle Ayr South Mine 47

13 Typical Mining Section - Belle Ayr South Mine . . . 48

14 Coal Thickness - Belle Ayr South Mine 49

15 Belle Ayr South Drainage Basin 61

16 Hydrologic Monitoring Station Locations - Belle Ayr South Mine 66

17 Surface and Ground Water Rights - Belle Ayr South Mine 67

18 Vegetation Map - Belle Ayr South Mine 70

Page

Figure 19 Topography after Reclamation is Completed - Pasture and Grazing Alternative - Belle Ayr South Mine 129

20 Artist's Conception of Final Reclamation Showing Two Lakes along Restored Caballo Creek 130

TABLES

		Page
Table 1	Soil Management Interpretations in Three Classes: L-Low, M-Moderate, H-High	37
2	Proximate, Ultimate, Btu, and Sulphur Analyses of a Representative Coal Sample from the Belle Ayr South Mine	51
3	Major Oxide Composition of the Laboratory Ash of 8 Coal Samples from the Belle Ayr South Mine	52
4	Quantitative Determinations for 12 Trace Elements in 8 Samples of Coal from the Belle Ayr South Mine .	53
5	Semiquantitative Spectrographic Analyses for 19 Trace Elements in 8 Samples of Coal from the Belle Ayr South Mine	54
6	Common Vegetative Species Found on the Belle Ayr South Mining Plan Area	73
7	Estimated Cumulative Emissions from Locomotives in the Study Area	91

PREFACE

In January 1974, the Departments of Interior and Agriculture and the Interstate Commerce Commission decided that, under provisions of Section 102 of the National Environmental Policy Act of 1969, an environmental impact statement must be prepared before any decision could be made on pending proposals for major development of federally-owned coal in the Eastern Powder River Basin of Wyoming. At that time, there were four major strip mine plans pending approval before the Department of the Interior. There was also pending before the Interstate Commerce Commission proposed construction of a railroad some 113 miles in length, between the Belle Ayr Mine spur southeast of Gillette, Wyoming, and Douglas, Wyoming. This railroad was to serve the coal mines proposed to be developed along the proposed right-of-way in the basin. The construction of this railroad line, the four mining proposals, as well as a number of other anticipated or possible future coal-related developments and all their impacts on the environment, were evaluated in an environmental impact statement entitled "Proposed Development of Coal Resources in the Eastern Powder River Basin of Wyoming." The final statement was filed with the Council on Environmental Quality by the Department of the Interior on October 18, 1974.

Part I of that final environmental impact statement (herein after designated FES 74-55) was devoted to a regional analysis encompassing the existing environment, all projected coal development and the cumulative effect of this development on the environment. Parts II through VI of the FES specifically dealt with the four mine plans and the construction of the railroad.

Due to the increased nationwide demand for low sulphur coal for the generation of electricity, it was anticipated that a number of large strip coal mines, in addition to those four mines considered in Parts III through VI of FES 74-55, would also be proposed for development of Federal coal leases in the near future in the Eastern Powder River Coal Basin. Accordingly, the regional analysis of FES 74-55 included data and information from every proposed operation known to be under consideration by the various leaseholders in the study area. In this way the cumulative impacts of the total potential development could be assessed. Subsequent to initiation of preparatory efforts for FES 74-55 and prior to its filing in final form, other proposed mining and reclamation plans for development of existing Federal coal leases in the area were filed for approval with the Geological Survey, Department of the Interior, as required by law.

Because of the submission date, these plans could not be included for site specific analyses in FES 74-55. In the assessment which follows, the site specific aspects of the proposed mining and reclamation plans for the South Belle Ayr Mine of the Amax Coal Company, are analyzed using information and data previously published in FES 74-55 together with information gained from field observations and company reports. Part I of FES 74-55 is incorporated herein by reference.

CHAPTER I

DESCRIPTION OF PROPOSED ACTION

Background and History

The existing Belle Ayr South Mine is operated by the Amax Coal Company. It is located about 15 miles southeast of Gillette, Wyoming, and 5 miles east of State Highway No. 59, which connects Gillette and Douglas, Wyoming (Figure 1). From the highway, the only part of the mine visible is the storage silos. County Highway T-7 crosses the property in a north-south direction (Figure 2).

Coal lease Wyoming 0317682, containing 2,440.31 acres, was offered for sale by competitive bidding on June 25, 1965. Amax was the only bidder at $26.50 per acre. The lease was issued on September 1, 1965. A copy of Federal coal lease Wyoming 0317682, including a legal description of the land is in Appendix A.

All of the surface overlying the Federal coal lease is privately owned and Amax has purchased 2,280 acres of this land. The company also owns the surface and coal rights on an additional 1,120 acres of private holdings.

The Federal lease (Wyoming 0317682) is a continuing lease subject to reasonable readjustment of terms on a 20-year basis. It provides for a royalty of 17½ cents a ton (2,000 pounds) for coal mined the first 10 years of the lease and 20 cents a ton for the remainder of the first 20-year period of the lease. The annual rental is set at $0.25 per acre for the first year, $0.50 for the second, third, fourth,

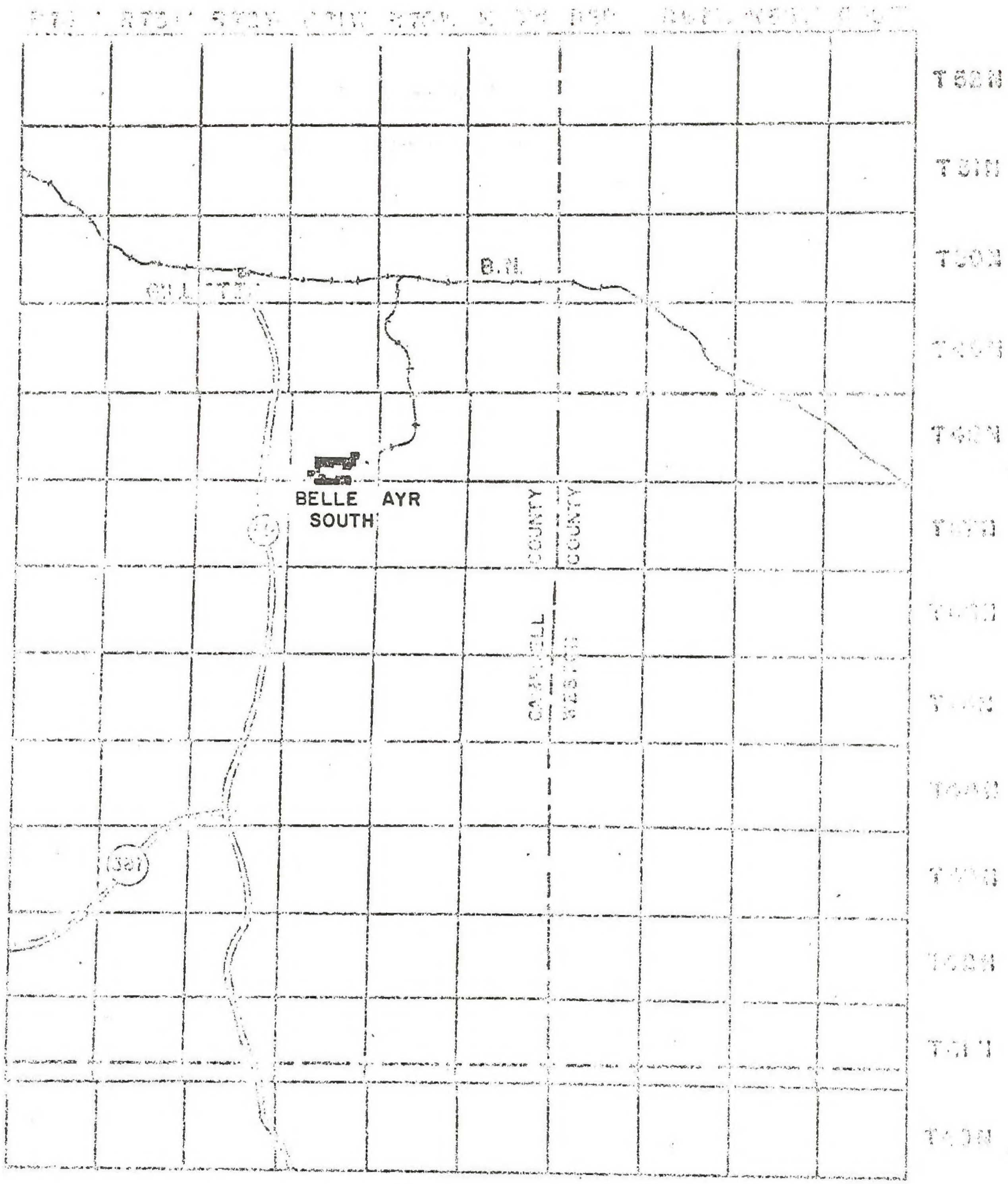

T52N
T51N
T50N
T49N
T48N
T47N
T46N
T45N
T44N
T43N
T42N
T41N
T40N
B.N.
GILLETTE
BELLE AYR
SOUTH
59
387
CAMPBELL
COUNTY
WESTON
COUNTY

Figure 1

Location of Belle Ayr Coal Mine - Amax Coal Company
Campbell County, Wyoming

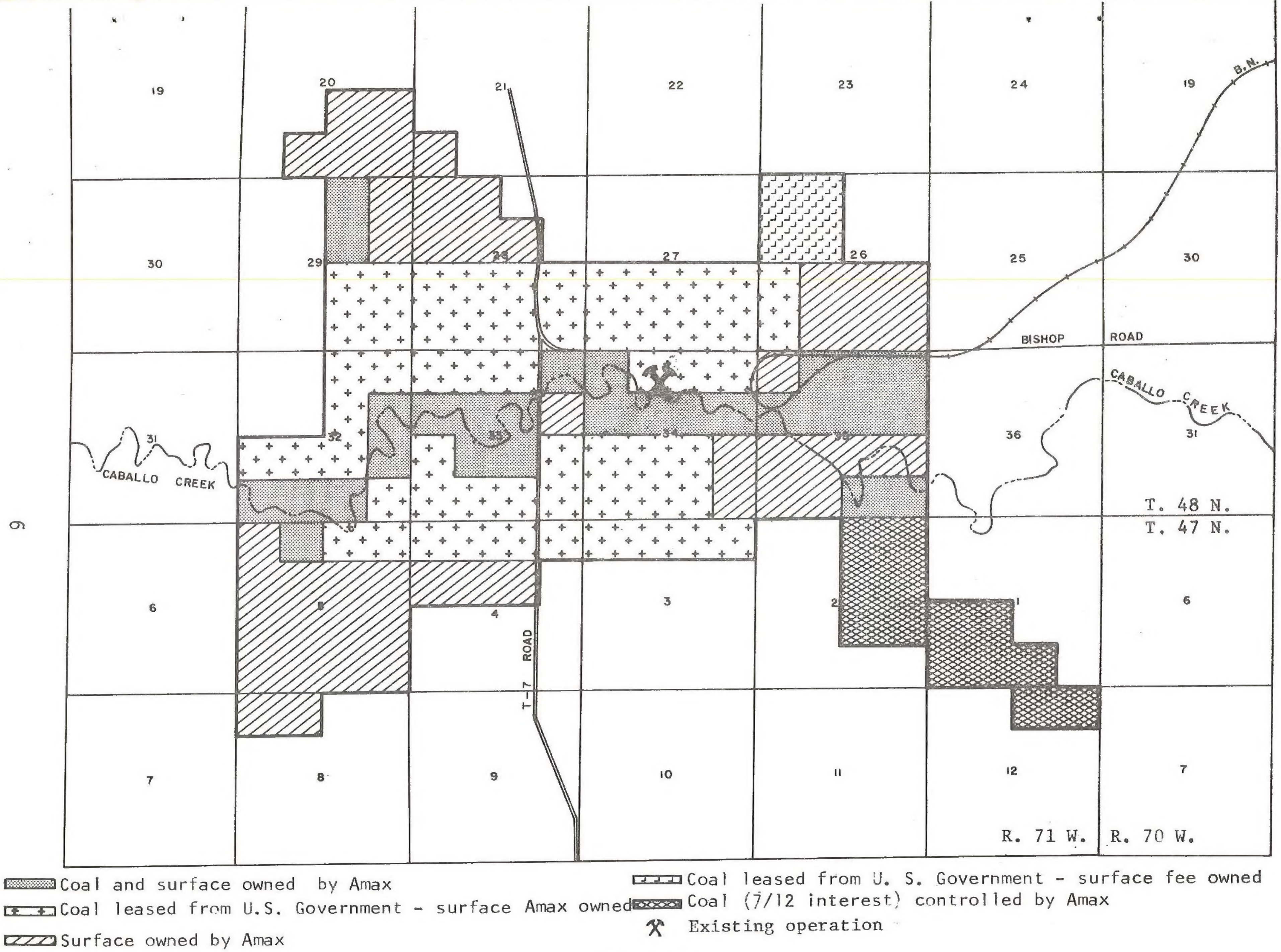

19
20
21
22
23
24
19
B.N.
30
29
28
27
26
25
30
BISHOP ROAD
CABALLO CREEK
31
32
33
34
35
36
31
T. 48 N.
T. 47 N.
6
5
4
3
2
1
6
T-7 ROAD
7
8
9
10
11
12
7
R. 71 W.
R. 70 W.
▒ Coal and surface owned by Amax
✚ Coal leased from U.S. Government - surface Amax owned
▨ Surface owned by Amax
⊔ Coal leased from U. S. Government - surface fee owned
▩ Coal (7/12 interest) controlled by Amax
⚒ Existing operation

Figure 2

Property Map - Amax Coal Company - Belle Ayr South Mine and fifth years, respectively; and $1.00 per acre for the sixth and each succeeding year during the continuance of the lease, such rental for any year to be credited against the first royalties as they accrue under the lease during the year for which the rental was paid. Minimum annual royalty based on production is set at $1.00 per acre or fraction thereof starting the sixth year of the lease.

The lease presently contains no special stipulations for reclamation,however Section 5 of the lease covers protection of the surface and provides for reclamation of the land. Also, no mining plan will be approved which does not provide for adequate reclamation.

On February 17, 1972, the company submitted their first mining plan embracing the initial mining to be done on both federally-owned and privately owned coal in the W 1/2 NE 1/4 and the NW 1/4 of section 34. This plan was approved by the Area Mining Supervisor on October 13, 1972. Shipments of privately owned coal started in early 1973 and by September 1973 the mining of federally-owned coal had started. A modification of the original plan was approved by the Area Mining Supervisor on June 1, 1973.

Purpose of Proposed Project

On November 7, 1973, the Amax Coal Company submitted an incomplete mining plan for their Belle Ayr South Coal Mine outlining mining proposed on the property through 1997. The plan encompassed mining 2,200 acres of Federal coal land plus 690 acres of fee coal (Figure 2). The company has long-term contracts which will require mining all of the available coal on both the Federal lease and the privately owned acreages. Additional information concerning proposed mining and reclamation on the property was subsequently received by the Area Mining Supervisor, U.S. Geological Survey, and the completed proposal is evaluated herein. Because of the large volume of material submitted by Amax Coal Company, it was impractical to include all of the technical and specialized analyses and data contained therein in this statement. However, the statement does contain the information necessary to permit assessment of the potential impacts of the proposed mining activity.

The mining plan and all supporting environmental data submitted by Amax are on file at the office of the Area Mining Supervisor, Conservation Division, U.S. Geological Survey, Billings, Montana, and can be reviewed by the public at that location. (Appendix B.)

The company could mine for several years its privately owned coal without requiring the approval of a mining plan by Federal officials. However, such a course of action would complicate reclamation plans for the entire mine. In order to permit the most orderly development of the mine, a further modification of the October 13, 1972, plan covering 99 acres was approved on April 30, 1974, by the Area Mining Supervisor, after review and concurrence of the proposed action by the Department of the Interior. That plan included 72 acres of federally leased coal.

Specific Site Location

The service buildings, coal storage area, and unit train loading facilities are located in section 34, T. 48 N., R. 71 W. Most of the railroad loop is in section 35 (Figure 2). The service buildings and railroad loop are located to the east of the coal reserves.

Gillette, the county seat of Campbell County, is located about 15 miles north of the mine and has a population of about 7,500 people. Douglas, Wyoming, (population about 3,000) is located 100 miles to the south and Casper, Wyoming, (population about 40,000) is about 115 miles from the mine. The smaller communities such as Midwest and Moorcroft would likely be influenced very little by the mining operation.

Stages of Implementation

The following description of mining and reclamation activities is taken, with modification, from the mining and reclamation plan, and supporting data, submitted by Amax Coal Company.

Proposed mine layout and production

The mining plan covers the proposed mining operation for 25 years. It outlines in detail the area to be mined each year (Figure 3) and the reclamation procedures to be followed. The mining plan is based on meeting the following production schedule:

Year	Tons/Year
1973	897,000 (Actual)
1974	3,312,000 (Actual)
1975	5,000,000
1976	8,000,000
1977 to 1996	15,000,000 tons per year
1997	14,000,000
TOTAL	331,000,000

The mine was opened during 1973 near the center of the N½ of section 34. About 23 acres of coal was uncovered and the overburden averaging 30 feet in thickness was deposited just east of the coal outcrop line. The company is now stripping another 23 acre tract to the north of the original pit. The overburden is up to 50 feet thick in this pit. During 1975 the pit will be extended 1,300 feet toward the east until all of the minable coal is taken along the outcrop. In 1976

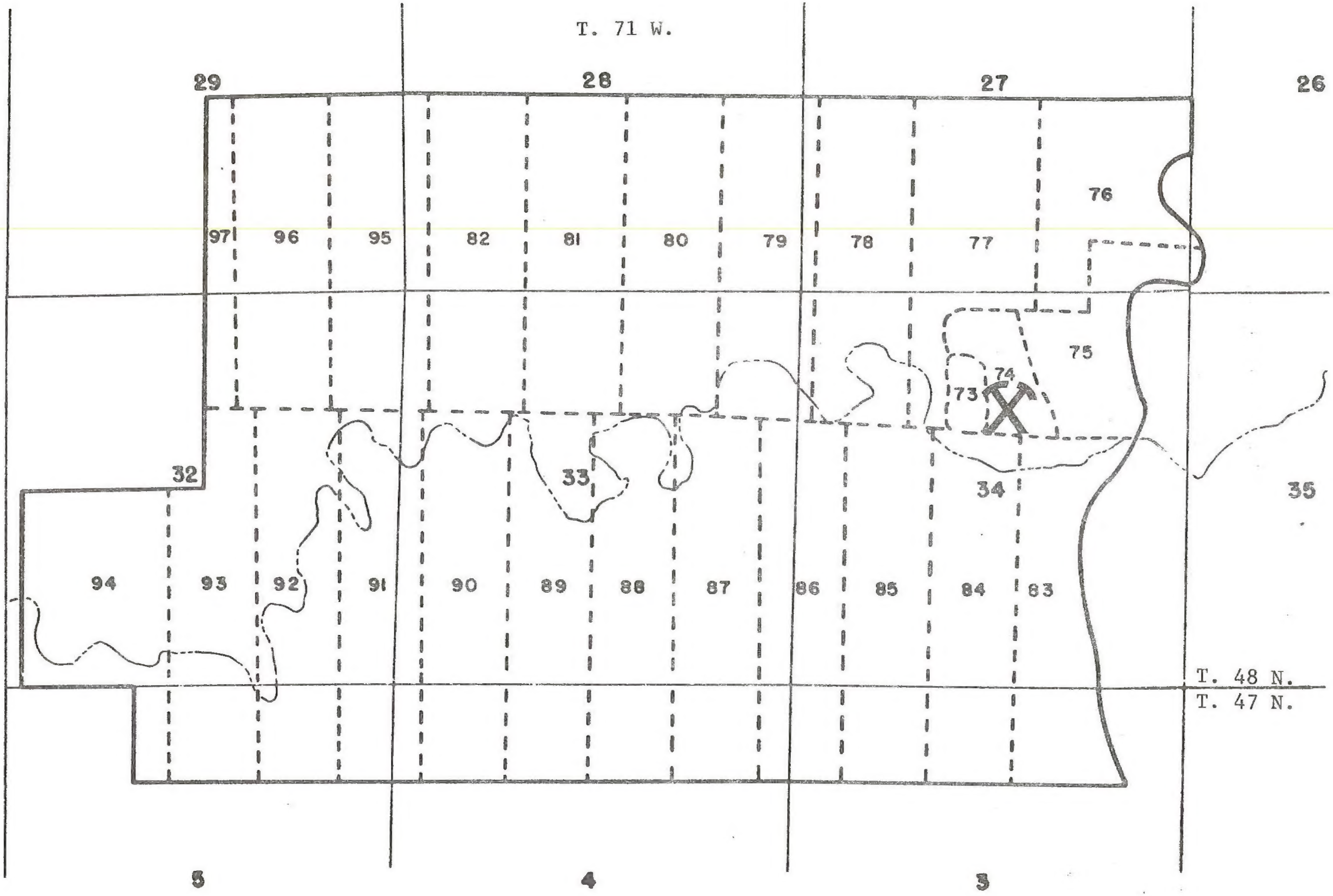

T. 71 W.
29
28
27
26
97
96
95
82
81
80
79
78
77
76
75
74
73
32
33
34
35
94
93
92
91
90
89
88
87
86
85
84
83
T. 48 N.
T. 47 N.
5
4
3

Figure 3

Area to be mined annually - Belle Ayr South Mine

⚒ – Existing operation

the mining operations will be extended along the outcrop to the northern boundary of the area to be mined.

The mining will then continue to the west until 1982 when the western line of section 28 is reached. At full production, a strip about 4,300 feet long and 1,300 feet wide which includes 126 acres, will be mined each year. In 1983 the mining operations will be moved to the coal outcrop south at Caballo Creek. The mining will again extend to the west and a strip 4,800 feet long by 1,150 feet wide will be mined each year.

The overall dip of the coal bed is about 1 percent to the west. Caballo Creek flows to the east through the center of the property. The overburden obviously increases to both the north and south from the stream and also to the west because of the stream gradient. The overburden varies from 15 feet near the outcrop up to 250 feet in thickness at the northwest corner of the proposed mining area. The thickness of the overburden is 187 feet near the point where Caballo Creek enters the property.

By mining north-south strips the company is taking areas of thick overburden along with areas of little overburden near the stream. This is important for reclamation because some of the spoils from the areas of thick overburden will be used to fill the voids created by mining the thick coal bed with little overburden.

Mining equipment

Mining equipment used presently at the Belle Ayr South Mine is listed below:

No.	Equipment	Major Use
1	Bucyrus-Erie Model 295 13-yard shovel	Loading overburden
1	Bucyrus-Erie Model 295 24-yard shovel	Loading coal
4	End-dump trucks 75-ton	Haul coal and overburden
7	End-dump trucks 120-ton	Haul coal and overburden
1	Caterpillar Model 627 Scraper 21-yard	Handle topsoil material
1	Caterpillar Model 621 Scraper 21-yard	Handle topsoil material
1	Caterpillar Model D-8 Tractor	Clean coal bed and level spoils
3	Michigan Model 820 Rubber-tire tractor	Build roads and level spoils
1	Caterpillar Model 12 Road grader	Maintain roads and finish grading spoil piles
1	Champion Model 305 Road grader	Maintain roads and finish grading spoil piles

The company has ordered 7 additional Model 295 shovels and 5 additional 120-ton trucks.

Mining procedures

Soil material removal

The soils in the leased area reflect the type of underlying rock. The topsoil materials are characterized by clays and occasional sandy loams. The overburden material will therefore include semi-consolidated clays, silts, and sands. The topsoil or root zone area is generally about 12 inches thick on the sloping hillsides but may be thicker in the valleys where soil has washed down from the steeper slopes. The clinker hills on the property are nearly barren of topsoil.

The company proposed to remove all of the suitable soil material from the active mining area. This material is from 0 to 3 feet thick in the area to be mined. If enough topsoil material is available, it will be spread to a depth of 2 feet on the reclaimed spoil piles.

Overburden removal

The company is now using a shovel and trucks to remove overburden and proposed to continue this practice. The overburden has been placed in undisturbed areas and graded to blend with the existing topography. The railroad loop encloses about 60 acres which has been filled with overburden material, leveled, and partly planted with wheat. An additional 30 acres of undisturbed land south of the office buildings and east of the coal outcrop has also been covered with spoils and graded to blend with the existing topography. This overburden will not be returned to the pit. Future overburden will be placed in abandoned mine pits when enough coal has been mined to provide the necessary room.

The company proposes to experiment with a bucket wheel excavator loading into trucks in 1975. If this is successful, they may attempt to combine a belt conveyor system with the excavator to remove the overburden (Figure 4). Both this system and the shovel and truck system are very flexible. Overburden unsuitable for plant growth will be selectively placed on the bottom of the spoil piles and the better soil material will be placed near the top. With these systems, the overburden will be taken in two or more benches, each 35 feet high, and danger from collapse of highwalls can be reduced.

Coal loading

The 70-foot coal bed will be mined in two 35-foot benches. The coal is presently being loaded by a 24-yard shovel without blasting and this practice may continue into the future.

However, the company also plans to experiment with bucket wheel excavators to remove both the coal and the overburden. If successful, small machines will be used on each coal bench to load directly onto a belt. The belts from each bench will feed onto another belt which will carry the coal to the preparation plant.

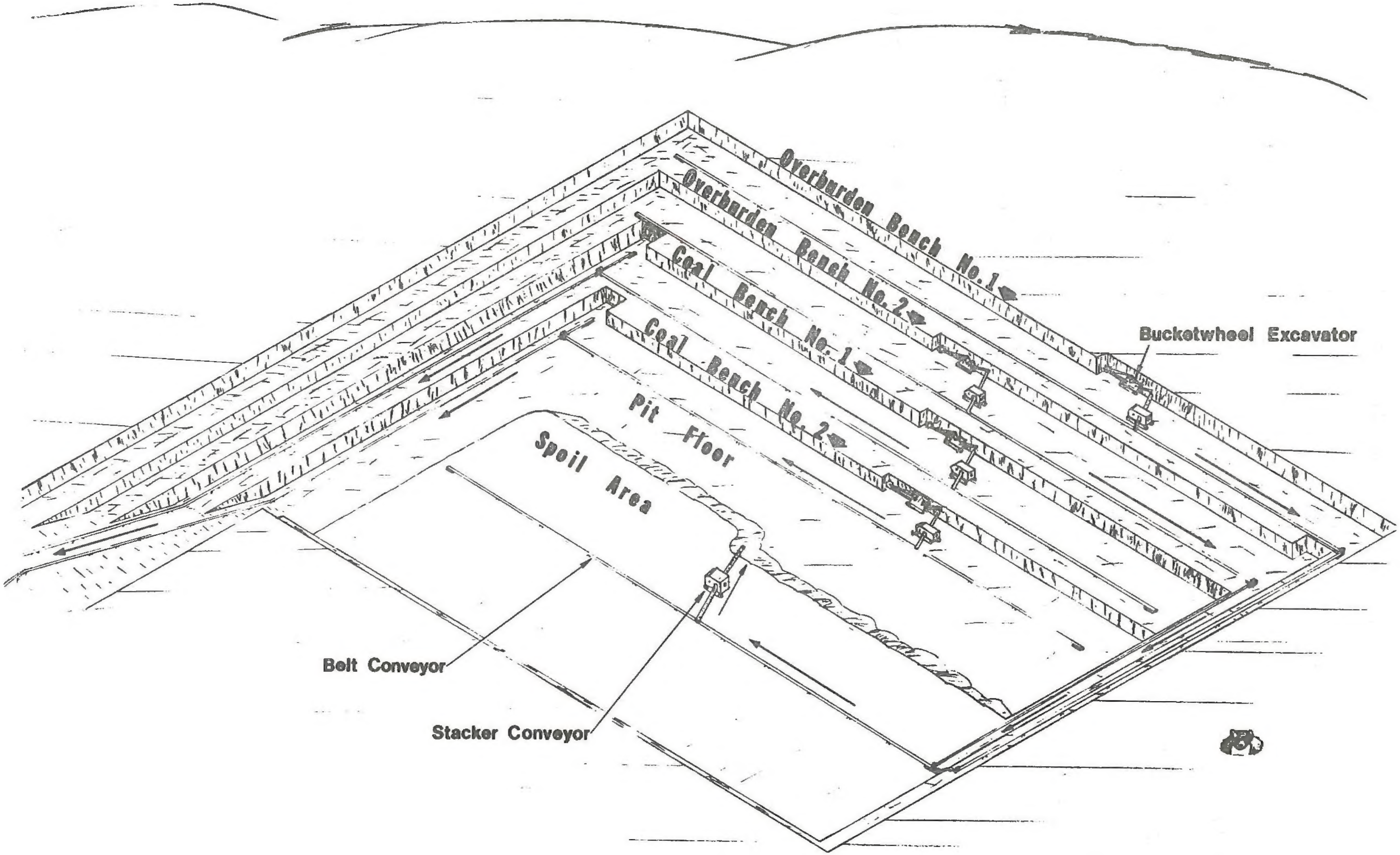

Overburden Bench No.1
Overburden Bench No.2
Coal Bench No.1
Coal Bench No.2
Pit Floor
Spoil Area
Bucketwheel Excavator
Belt Conveyor
Stacker Conveyor

Figure 4

Isometric View of Proposed Mining with Bucketwheel Excavator-Conveyor Belt System

Reclamation

All reclamation activity on Federal coal lands must conform to both Federal laws and regulations as well as to the requirements of the Wyoming Environmental Quality Act--1973. Before any mining may be started in Wyoming, the State requires the operator to obtain a permit which allows the operator to mine in conformance with a State-approved reclamation plan.

Grading

The company has proposed alternative methods of reclamation in their mining plan. Under plan No. 1, Caballo Creek would be returned approximately to its original channel at its original level. The reclaimed land would be sloped on a slight uphill gradient away from the channel and would gradually change to a slope in the transition area that would blend in with the contours of the adjacent undisturbed lands. Some material from the areas of thick overburden would have to be moved to the areas with little overburden to bring the surface to this level. The land would be returned to pasture and grazing use.

Alternate plan No. 2 calls for leaving the reclaimed surface at approximately the same configuration as the original land except the surface would be lowered by a distance about equal to the thickness of the coal (70 feet). This would leave part of the surface below the water table and would create a lake of approximately 930 acres with an average depth of 20 feet. A variation of plan No. 2 calls for creating two small lakes instead of the one big lake.

The methods proposed by the company to handle overburden all provide the flexibility necessary to selectively place toxic and poorer soil materials on the bottom of the spoil piles and the better soil materials near the top. The company is presently placing the better soil material inside the rail loop and dumping some of the overburden unsuitable for plant growth north of the office buildings. This dump will eventually be covered with good soil and reclaimed to blend with the landscape. The company is also placing part of the overburden in the mined-out pit area. They will continue to place the remainder of the overburden in the dump north of the office buildings until enough room is available in the pit area to accomodate all of the spoil.

Planting and revegetation

The method used to seed the regraded spoil piles will be determined by two experimental programs now in progress. One program is being conducted by Meadowlark Farms, Inc., in cooperation with the University of Wyoming, and is testing 22 species of grasses and legumes in a test plot on the spoil piles. The U.S. Forest Service is conducting the second experimental program to determine the survival rate of 8 selected trees and shrubs at an overburden disposal site.

The survival rate for the first growing season was as follows:

Tree or Shrub	Survival Rate
Green Ash	98.5%
Russian Olive	84.0%

Skunk Bush	65.4%
Juniper	52.4%
Silver Buffalo Berry	44.0%
Ponderosa Pine	40.8%
American Plum	30.7%
Siberian Pea Shrub	16.9%

The first seeding program was conducted by the company in the spring of 1972. At that time, 5 acres were planted along the diversion ditch levee with crested wheatgrass and sweet clover. At the same time, another 10 acres of disturbed land near the surface building was planted with Sodar Streambank Wheatgrass, sweet clover, and Rosana Western Wheatgrass. The results of these plantings have been satisfactory.

In May of 1973 the company planted 35 acres with a mixture of Rosana Western Wheatgrass, Fourwinged Salt Bush, and Green Needlegrass. The results here too have been encouraging.

In September of 1973 they planted 35 acres of Winter Wheat on the overburden disposal area inside the railroad loop. The company also cultivated a combination of abandoned fields in undisturbed land southeast of the railroad loop. Company officials reported they harvested 20 bushels of wheat per acre from inside the rail loop and 32 bushels per acre from the undisturbed land.

This experimental work was all done before the company started saving topsoil. The land was either leveled or graded to a rolling topography and planted without benefit of topsoil or irrigation.

Roads

The haul roads are and will be constructed from 80 to 120 feet wide and will be surfaced with clinker. Only 3 miles of haul road is needed to reach the lease boundary. The haul roads will be constructed on top of the reclaimed spoil to control dust, the active haulage roads will be wetted as necessary during the workday by a water spray truck. The company estimates that as much as 80,000 gallons of water per day could be used for this purpose during the hot windy summer season. The source of this water is primarily pit seepage.

Two gravel surfaced roads originally crossed the area to be mined. The Bishop road running east and west has been relocated ½ mile to the north along the edge of the proposed mine limits. County Highway T-7 now crosses the property in a north-south direction (Figure 2) and will be temporarily relocated to the west when it is reached by the mining. The roads are surfaced with clinker to reduce the dust, however, an Amax dust survey of the mine indicates that the county roads are still one of the sources of fugitive dust in the area (Appendix C).

Drainage

The water from the meandering Caballo Creek has been diverted by a newly constructed ditch around the south edge of the initial mine area. A small ditch on the north and west side of the active mine area protects the mine from surface water runoff. Since the coal to be mined is below the level of the creek, some water will be pumped from the mine into the drainage system.

A dam across Caballo Creek below the mine has served as a stock watering pond for many years. The company has increased this water storage by building another dam upstream. The water will be treated here, if necessary, before it is released downstream. Any sediments picked up in the new stream channel will have an opportunity to settle out in this pond. The company plans to build additional settling ponds during the course of mining.

At some time during the mining operation, water from Caballo Creek could be routed into a lake created by the mining operation. The water in this lake would probably be clean enough to support fish life. A similar lake at the Big Horn Mine near Sheridan, Wyoming, has been used as a fishing lake for many years.

Surface facilities

Very little additional surface plant construction will be needed at the Belle Ayr Mine to produce the projected 15-million tons per year production. Additioanl mining equipment will be needed but the coal storage, office and shop space, and unit train loading equipment is adequate to handle this tonnage. Figure 5 shows the location of the various surface facilities and the rail loop.

Railroad

An 18-mile railroad spur line has been constructed to the mine site from a point east of Gillette on the main line of the Burlington

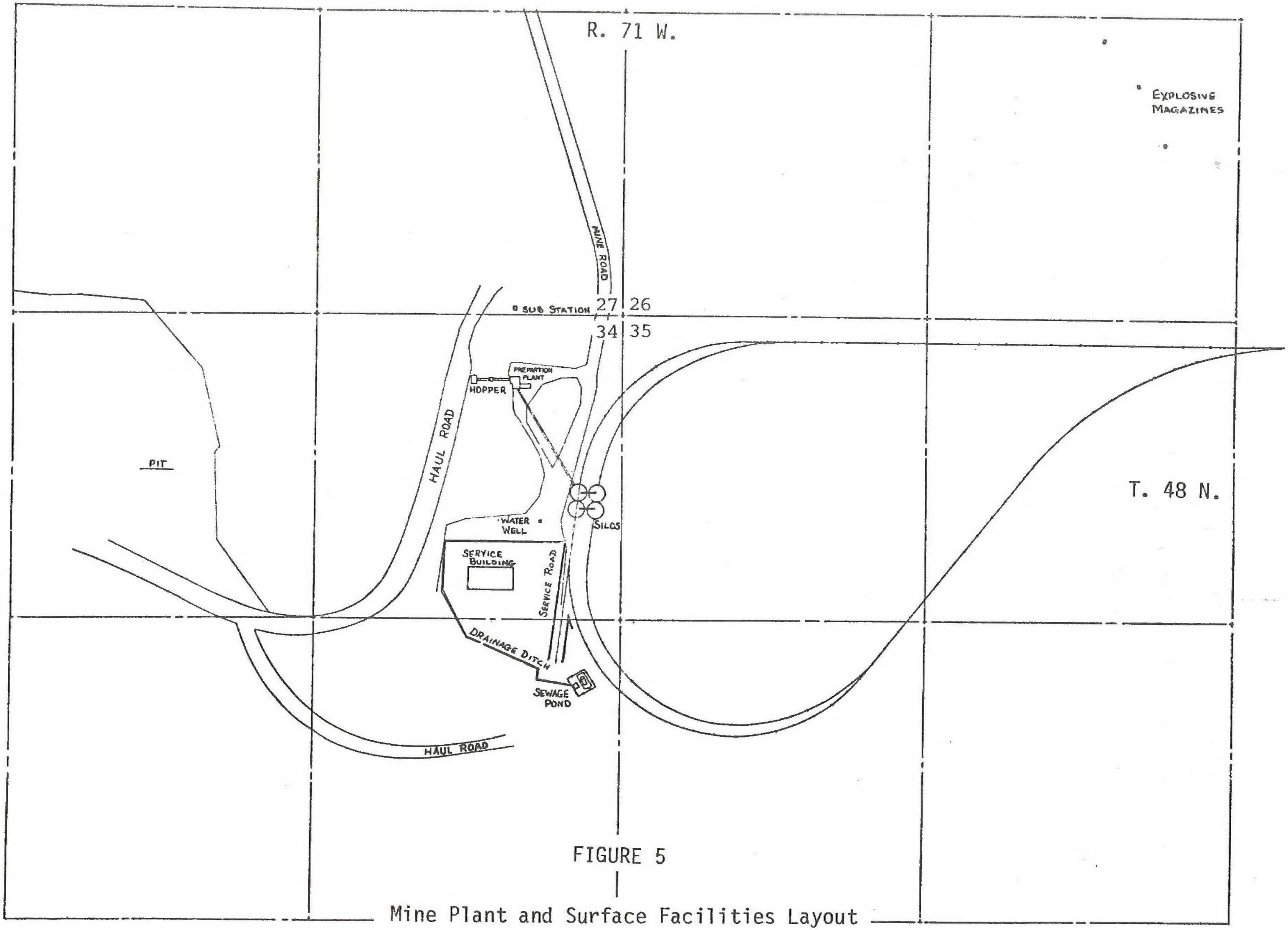

R. 71 W.
EXPLOSIVE MAGAZINES
MINE ROAD
SUB STATION
27
26
34
35
PREPARATION PLANT
HOPPER
HAUL ROAD
PIT
WATER WELL
SILOS
T. 48 N.
SERVICE BUILDING
SERVICE ROAD
DRAINAGE DITCH
SEWAGE POND
HAUL ROAD

FIGURE 5

Mine Plant and Surface Facilities Layout

BELLE AYR SOUTH MINE

Northern Railroad (Figure 1). At the mine, the railroad loop goes through the base of the coal storage silos and the coal is loaded by gravity into the railroad cars.

Mining equipment

The company is presently using a Bucyrus-Erie "295" electric crawler-mounted loading shovel with a 24-yard bucket to handle coal. The overburden is loaded with the same model shovel with an 18-yard bucket. They have ordered 7 loading shovels identical with the ones now in use for delivery within the next year. They have also ordered 5 new trucks each with 120-ton capacity to supplement the 11 trucks which are presently in use. All of the trucks will be rubber-tired, off-road, end-dump vehicles. As the overburden becomes increasingly thicker over the coal, more of the equipment will be needed full time in the stripping operation.

The company plans to experiment soon with an electric-powered bucket wheel excavator. The wheel will make two revolutions per minute and will be equipped with 8 buckets each with 2-yard capacity. If this machine handles coal and overburden more efficiently than the truck and shovel operation, several bucket wheel excavators will be purchased. They would load continuously onto a belt system which would deliver coal to the storage area and overburden to the mined out areas.

The trucks dump coal into a 250-ton hopper. The coal is carried by a conveyor to a building containing crushing equipment. It is then carried by a second conveyor to one of two coal storage silos each holding 12,000 tons of coal. The unit trains of 100 to 110 100-ton cars travel through the base of these silos and are loaded at the rate of about 4,000 tons per hour. At the present rate of production, 7 unit trains leave the property weekly. At full production of 15,000,000 tons per year, about 29 unit trains per week will be required.

Two more silos of the same size are under construction adjacent to the original silos. Coal will be loaded from the new silos into cars on a separate rail loop which will be constructed just inside the present loop. Coal will be loaded at the rate of 6,000 tons per hour on the new facility.

The train loading equipment is enclosed in the base of the silos and is protected from the wind. Very little dust escapes to the atmosphere while the railroad cars are being loaded. The coal crushing equipment has a vacuum dust collection system which gathers the dust in the building and eventually returns it to the coal circuit.

A service building with 20,000 square feet of space has been completed. The mine office, engineering office, and shop facilities are located in the service building. Three drilled wells supply water to the service building complex at a rate of about 2,500 to 4,000 gallons per day. The sewage from this unit is handled by a lagoon-type aeration plant which was designed to handle up to 300 families.

Power

Electric power for the operation is supplied to the mine via a 69,000 volt transmission line from the Wyodak Power plant east of Gillette, Wyoming. The power is delivered to a substation located north of the plant facilities where it is reduced to 4,160 volts for use by the shovels. From this main substation the power is connected to the preparation plant, silo complex and service building where it is further reduced to 480 volts or lower for use in the various facilities and machinery.'

Transportation and marketing

All of the minable coal on the property has been committed to power plants in the States of Colorado, Texas, Kansas, and Iowa. The coal will be loaded on 100-car unit trains. Each train will transport about 10,000 tons of coal. When production reaches 15 million tons per year, about 29 unit trains per week will be required to handle the production.

CHAPTER II

DESCRIPTION OF THE EXISTING ENVIRONMENT

Climate

The description of general climate, temperature, and precipitation in Volume I, pages I-115 to I-126 of FES 74-55 adequately characterizes the climate and meteorologic conditions on the Amax lease on Caballo Creek.

Data from the Gillette weather station, which is within 15 miles of the Amax lease, shows the following variance in climatic factors:

Temperature	-40°F to 107°F
Mean monthly temperatures	21.9°F in January to 71.9°F in July
Average 28°F frost-free period (May 6 to September 30)	127 days
Chill factor in winter	-60°F to -70°F minimum
Relative Humidity Range	5 percent to 100 percent
Average relative humidity range	45 percent to 55 percent
Average wind speed	10 to 12 miles per hour
Average rainfall	14.00 inches per year
Average snowfall	47.8 inches per year

Tornados have occurred near the lease area.

The company installed a meterological station at the mine site in February 1974 (Figure 6). The station is instrumented with a Belfort weighing-recording precipitation gauge, an epic hydrothermograph in a cotton-region shelter, an epic recording anemometer, and a Belfort microbarograph. The station is presently recording temperature, relative humidity, atmospheric pressure, precipitation, and wind speed and direction.

Since the period of observation is relatively short, no summary conclusions can be attributed to the data generated by this station. However, a summary of the raw data obtained during the period of mid-February 1974 through June 1974 can be found in appendix D.

Figure 7 is a wind rose giving mean daily values of wind speed and direction for the period of March through August 1974 at the mine site.

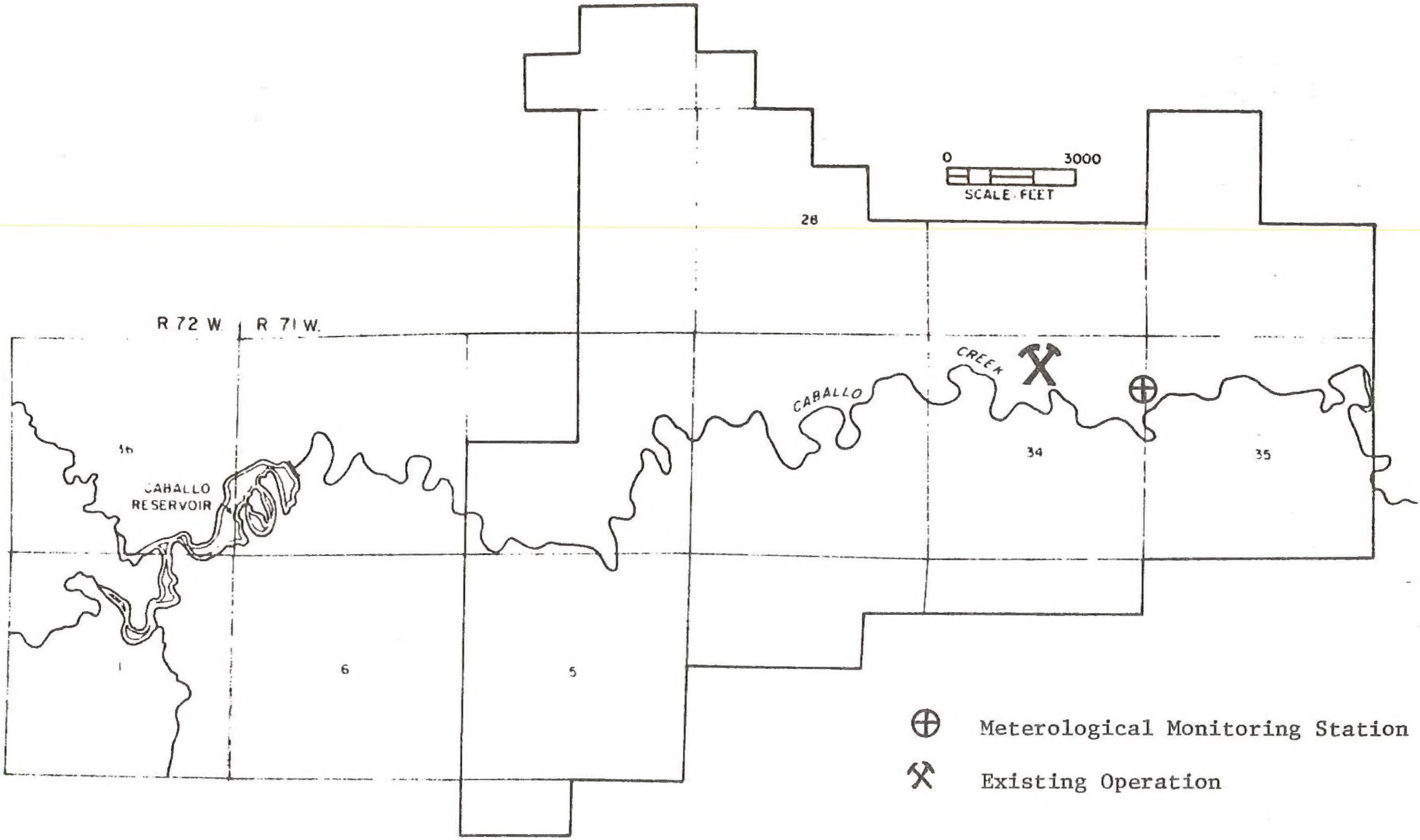
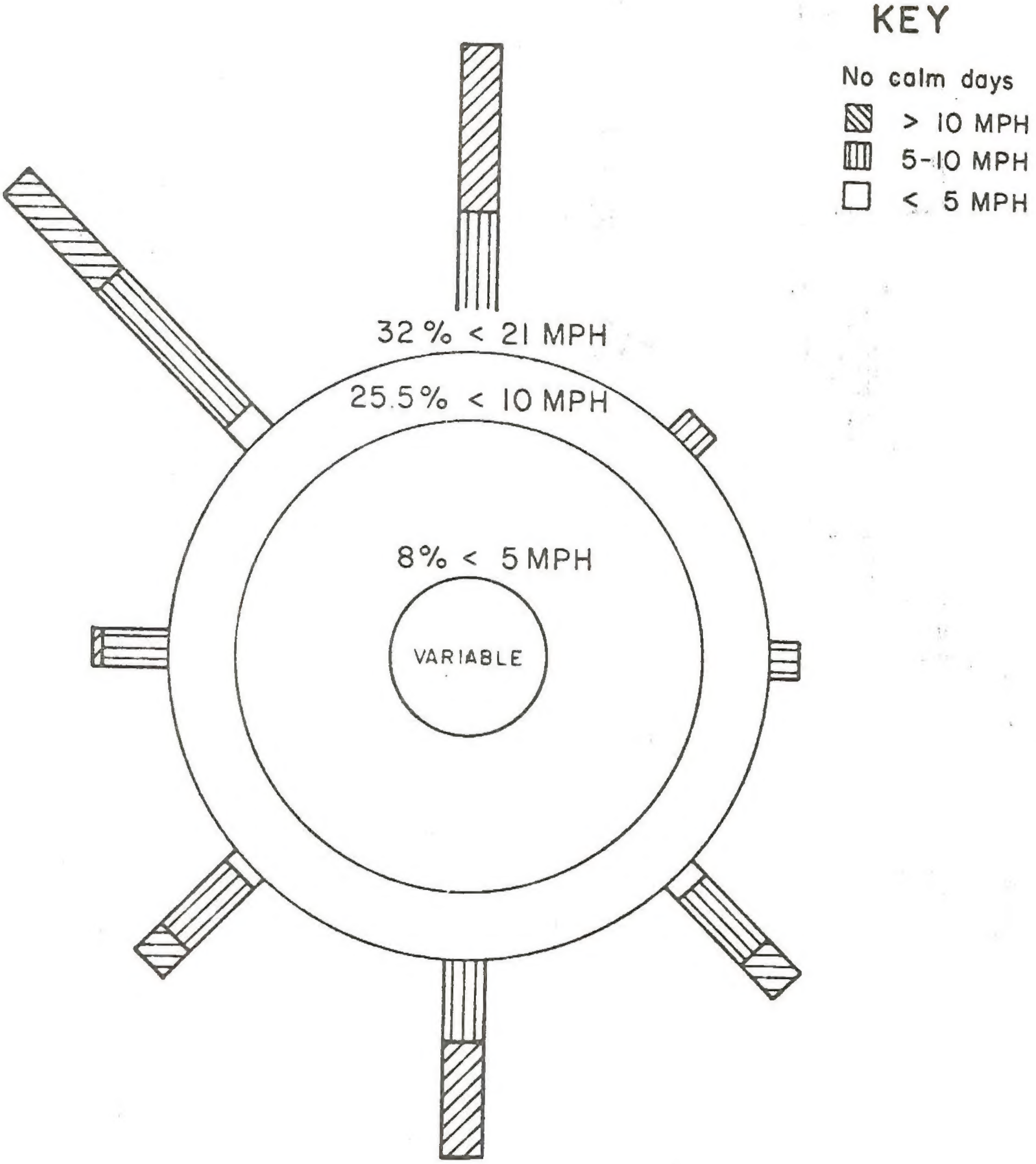

0
3000
SCALE FEET
28
R 72 W.
R 71 W.
CABALLO CREEK
36
CABALLO RESERVOIR
T. 48 N.
T. 49 N.
34
35
1
6
5
⊕ Meterological Monitoring Station
⚒ Existing Operation

FIGURE 6

Meterological Monitoring Station Location Map

BELLE AYR SOUTH MINE



MEAN DAILY VALUES
MARCH-AUGUST 1974

NOTE: Gage 12 ft. above ground.
Wind direction was termed variable if during the day the wind blew from more than two adjacent quadrants.
One-inch equals 10% of the time.

FIGURE 7

WIND ROSE

BELLE AYR SOUTH MINE

Air Quality

The Belle Ayr South Mine is located in the Wyoming Intrastate Air Quality Control Region. The air quality over the lease is described in detail in Part I of FES 74-55, pages I-127 through I-136.

Present air quality is estimated to be good. Emissions from the cities of Douglas and Gillette and power plants at Glenrock and Wyodak probably do not affect significantly the air quality of the lease area.

Mining has not visibly affected the air quality at the mine. The coal is naturally damp and very little coal dust enters the atmosphere from the present mining operations. The truck haul roads are sprinkled frequently and the coal storage facilities are enclosed and emit very little dust. It will require detailed studies of the atmosphere on a continuing basis to determine what effect the mining operations have. None of these studies have been completed; however, the methods used and some preliminary data are available and are presented in appendix C.

Topography

The Belle Ayr South Mine is in the Northern Great Plains Province of Fenneman (1931) and on the eastern flank of the topographic and structural downwarp of the Eastern Powder River Coal Basin. The basin is a topographic depression between the Big Horn Mountains to the west and the Black Hills to the east. The Eastern Powder River Coal Basin is a plateau of low relief, interrupted by low rolling hills and grasslands, capped by sandstone and clinker deposits, and transected by steep-sided gulleys, washes, and broad, alluviated valleys. This part of the basin is typically rolling grasslands on a dissected plateau, local escarpments, and minor badland topography.

Elevations on the lease vary from 4,450 to 4,600 feet. (Figure 8). Caballo Creek is the dominant surface feature and flows from west to east through the center of the area to be mined. The land near the stream is practically flat and has been cultivated for many years. From these fields the land rises to the north and to the south.

The northwestern part of the lease is covered with rolling upland grasslands. South of the river the terrain is more rugged with deeper washes and steeper slopes than those found north of the rivers. The burned coal bed with resultant clinker has formed a series of low abrupt hills near the eastern edge of the lease. Figures 9 and 10 show views of the topography of the leasehold in two different areas.

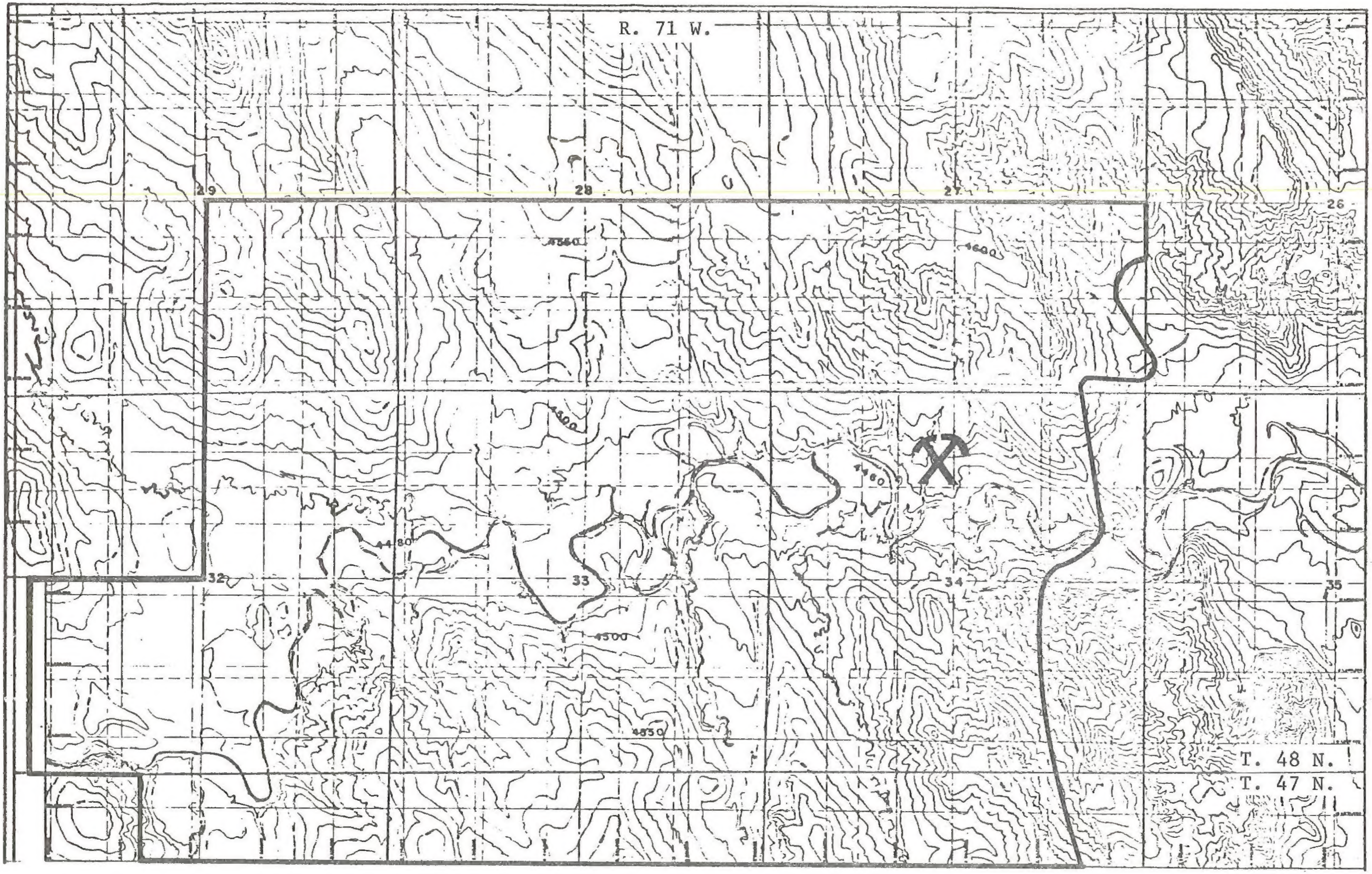

R. 71 W.
29
28
27
26
4560
4600
4500
4460
4480
32
33
34
35
4500
4550
T. 48 N.
T. 47 N.

Figure 8

Topography of the Amax Coal Company Mine Area

Belle Ayr South Mine

⚒ Existing operation

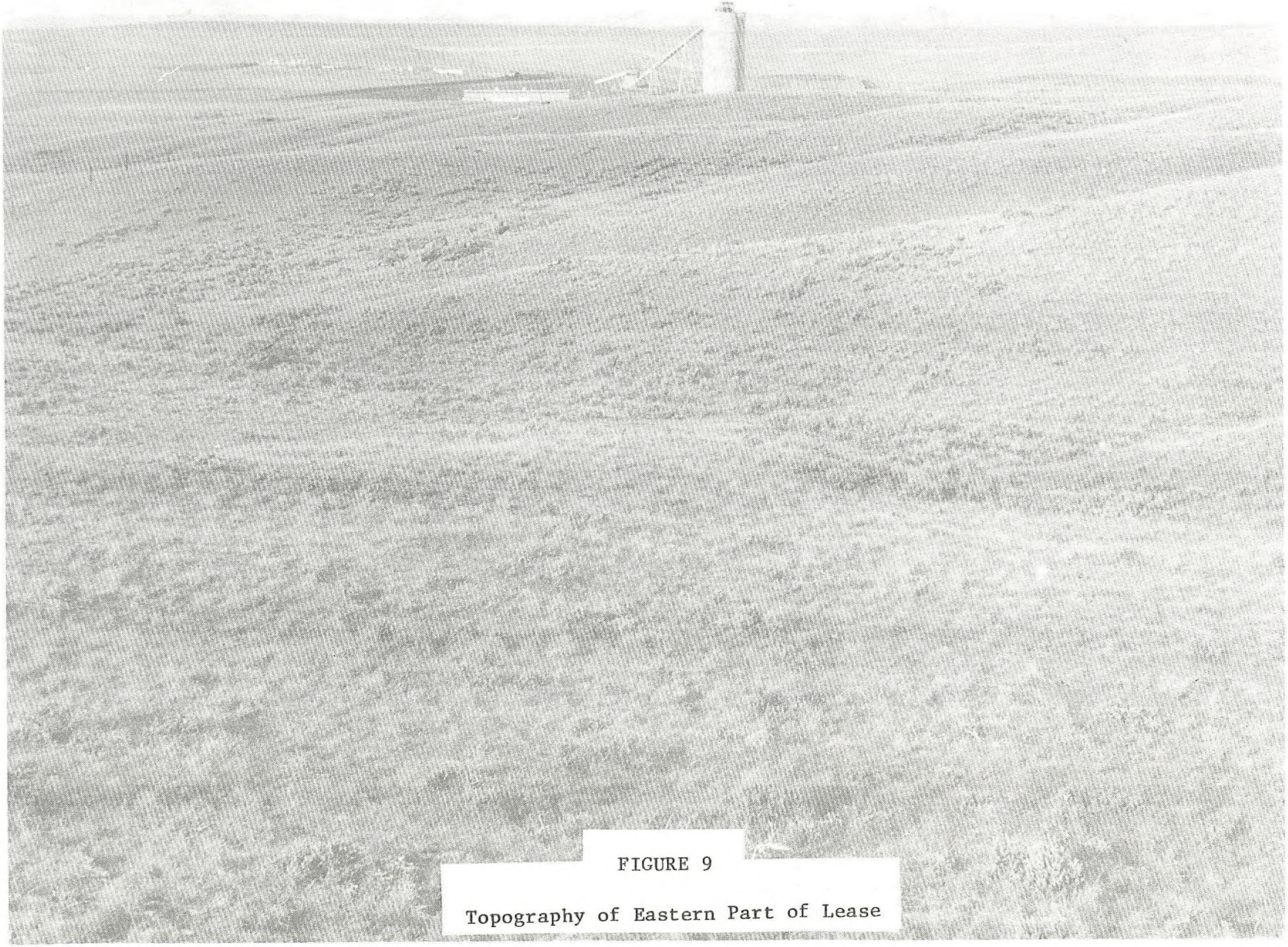


FIGURE 9

Topography of Eastern Part of Lease

BELLE AYR SOUTH MINE

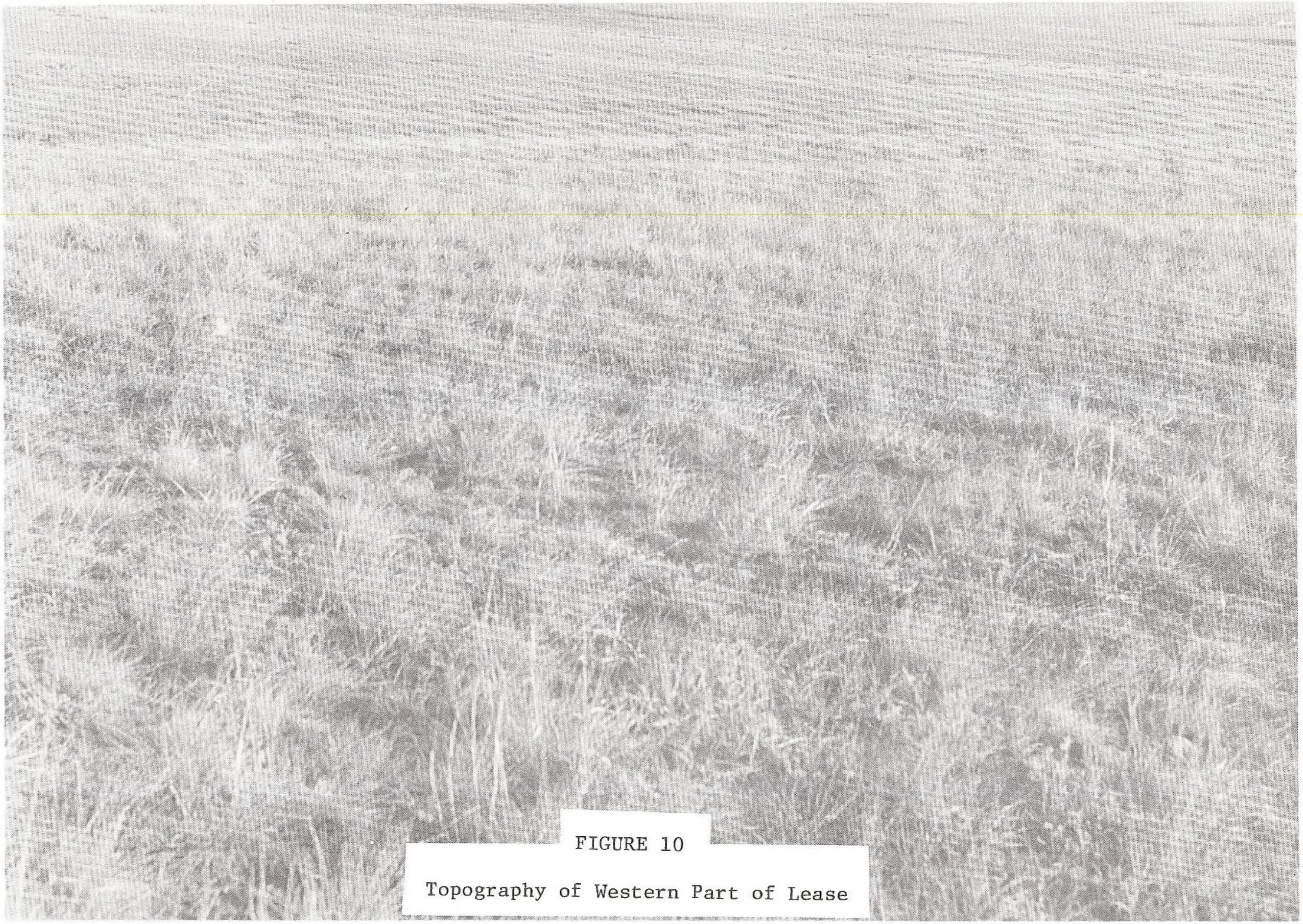


FIGURE 10

Topography of Western Part of Lease

BELLE AYR SOUTH MINE

Soils

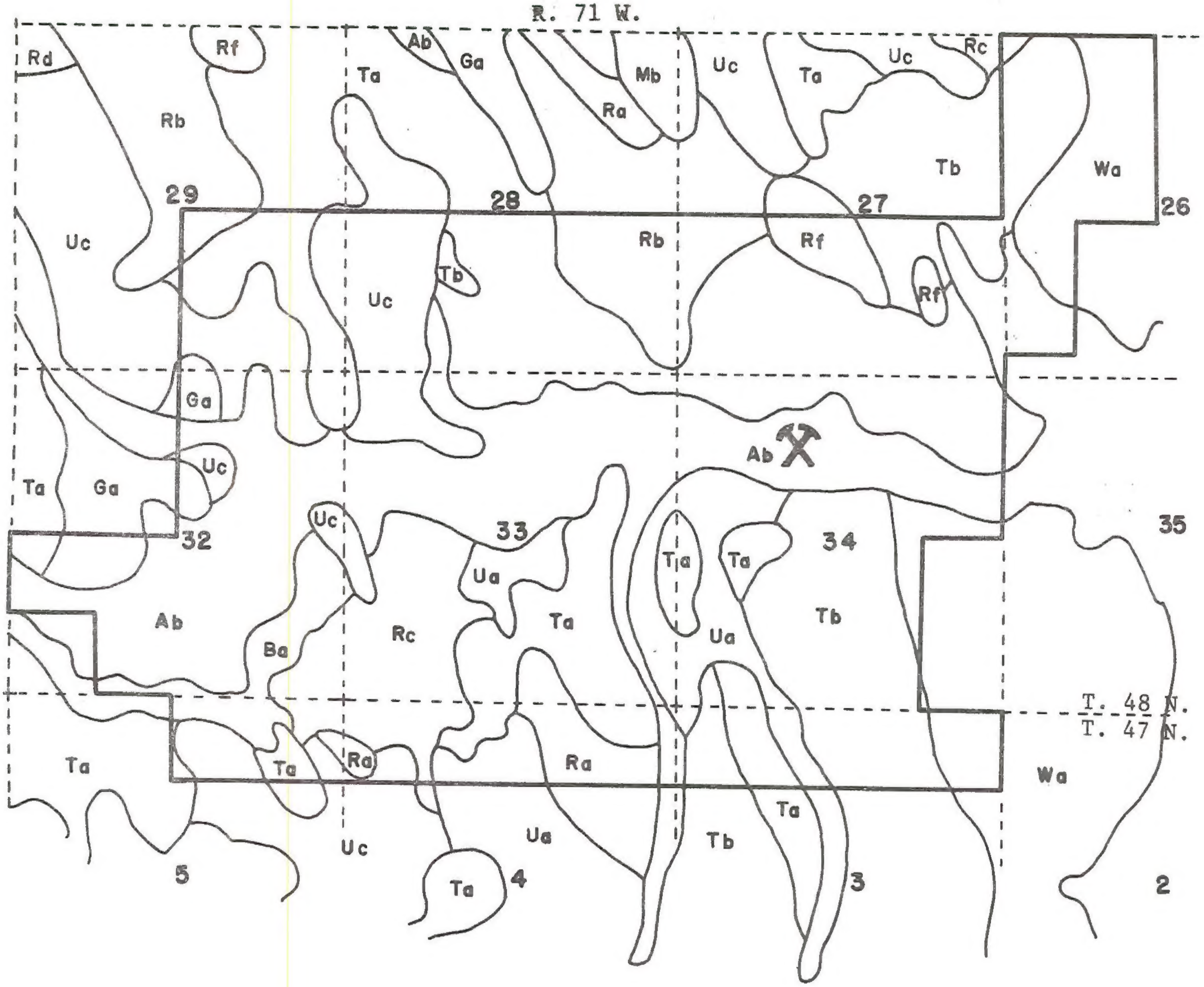
The Soil Conservation Service completed the field work for a general reconnaissance soil survey of Campbell County in 1939 and published the report in 1955. Although the report identified various soil series, it must be noted that each delineation included several other associated soil series. Therefore, specific interpretations for the identified soil series cannot be applied to the entire delineation shown on Figure 11. The SCS has indicated that many of the soil series identified in 1955 are subject to change as more detailed data is collected. The 1955 report is adequate for general planning only.

Based upon the 1955 reconnaissance soils report (USDA, Soil Conservation Service, 1955), 15 major soil mapping units occur on the mining lease area. Although each of these mapping units was not studied or mapped individually in 1939, an estimate of their suitabilities and limitations is discussed in Table 1, Soil Management Interpretations.

Ab-Arvada clay loam

Arvada clay loam occupies sloping terraces and alluvial fans that have been formed by local alluvium from upland soils. The soil has alkaline or saline areas and bare spots where wind erosion has removed the surface and exposed the clay subsoil.

The surface horizon is light brownish-gray friable clay loam about four inches thick. The soil reaction (pH) ranges from slightly to strongly alkaline. The subsoil is brown to gray clay to clay loam


R. 71 W.
Rd
Rf
Ab
Ga
Ta
Mb
Uc
Ta
Uc
Rc
Rb
Ra
29
28
27
Tb
Wa
26
Uc
Tb
Uc
Rb
Rf
Rf
Ga
Ab
Uc
Ta
Ga
Uc
33
34
35
32
Ta
Ta
Ua
Ab
Ta
Tb
Ba
Rc
Ua
T. 48 N.
T. 47 N.
Ta
Ta
Ra
Ra
Wa
Ta
Uc
Ua
Tb
5
Ta
4
3
2

LEGEND

SYMBOL	SERIES
Ab	Arvada Clayloam
Ba	Bankard fine sandy loam
Ga	Goshen loam
Mb	McKenzie Clay
Ra	Renohill clay
Rb	Renohill clay loam
Rc	Renohill rolling phase

SYMBOL	SERIES
Rd	Renohill loam
Rf-Rg-Rh	Rough Broken Land
Ta-Tb	Terry sandy loam
Ua-Ub	Ulm clay loam
Uc-Ud-Ue	Ulm loam
Wa	Wibaux-Searing complex
⚒	Existing operation

Source: USDA, Soil Conservation Service, Soil Survey, Campbell County, Wyoming July 1955.

Figure 11

General Soils Map - Belle Ayr South Mine

SOIL UNIT		EROSION HAZARD POTENTIAL		REVEGETATION POTENTIAL	SUITABILITY FOR SPRINKLER IRRIGATION	SUITABILITY FOR FINAL COVER FOR MINED LAND		SUITABILITY FOR TRANSPORTATION ROUTES	SUITABILITY FOR ROADFILL	SUITABILITY FOR SANITARY FACILITIES			SUITABIL FOR SMA COMMERCI BUILDIN
Symbol	% Slope	* Water	Wind			In, Available	Suitability			Septic-Tank Absorption Fields	Sewage Lagoons	Sanitary Landfills (Trench)	
Aa-Ab	0-5	M	M	L	L	0	L	L	L	L	L	L	L
	5-10	H	M	L	L	0	L	L	L	L	M	L	L
Ac	0-5	M	M	L	L	0	L	L	L	L	H	L	L
Ba	0-5	L	L	M	L	0	L	H	L	L	L	L	L
Fb	0-5	M	M	H	H	30	H	M	L	L	H	L	L
Ga	0-5	M	M	M	M	40	H	M	M	L	H	L	L
Mb	0-5	L	L	L	L	3	L	L	L	L	H	L	L
Ra-Rb	0-5	M	M	M	L	6	M	L	L	L	L	L	L
	5-10	H	M	M	L	6	M	L	L	L	L	L	L
Rc	10-20	H	L	M	L	6	M	L	L	L	L	L	L
	20-30	H	L	M	L	6	M	L	L	L	L	L	L
	30-40	H	L	M	L	6	M	L	L	L	L	L	L
Rd	0-5	M	M	M	M	8	H	L	L	L	L	L	L
	5-15	H	M	M	M	8	H	L	L	L	L	L	L
Rf-Rg	20-30	H	L	L	L	0	L	L	M	L	L	L	L
	30-40	H	L	L	L	0	L	L	L	L	L	L	L
	40-50	H	L	L	L	0	L	L	L	L	L	L	L
Rh	20-30	H	L	L	L	0	L	L	M	L	L	L	L
	30-40	H	L	L	L	0	L	L	L	L	L	L	L
	40-50	H	L	L	L	0	L	L	L	L	L	L	L
Ta-Tb	20-30	L	L	L	L	0	L	L	L	L	L	L	L
	30-40	L	L	L	L	0	L	L	L	L	L	L	L
Ua	0-5	M	M	L	L	6	M	L	L	L	L	L	M
Ub	5-10	H	M	L	L	6	M	L	L	L	L	L	M
Uc	0-5	M	M	M	M	16	M	M	M	L	L	L	M
	5-10	H	M	M	M	16	M	M	M	L	L	L	M
Ud-Ue	0-5	M	M	M	M	16	H	M	M	L	L	L	M
	5-10	H	M	M	M	16	H	M	M	L	L	L	M
Wa	5-10	H	L	L	L	8	L	M	H	L	L	L	H
	10-20	H	L	L	L	8	L	L	H	L	L	L	M
	20-30	H	L	L	L	8	L	L	M	L	L	L	L

* Estimated on-site erosion, bare soil conditions, L - 3,%./ac., M - 3-8 T./ac., H - 8T./ac.
Source of interpretations: 1. Descriptions from Campbell County. 2. Soil Conservation Service soil profile descriptions. 3. S.C.S. Form 5, Interpretation sheet. 4. Region 2, F.S. Guidelines for Soil Interpretations. 5. S.C.S. Guide for Interpreting Eng. Uses of soils.

TABLE 1 - SOIL MANAGEMENT INTREPRETATIONS
IN THREE CLASSES: L - LOW, M - MODERATE, H - HIGH

about 20 inches thick and has columnar to prismatic structure. The substratum is clay loam to clay to 60 inches or more. The soil reaction of the subsoil and substratum ranges from strongly to very strongly alkaline. The internal drainage is very slow. The exchangeable sodium percentage of the subsoil and substratum is high, more than 15 percent. There are an estimated 380 acres of these soils on the lease.

Ba-Bankard fine sandy loam

These soils are on gently sloping to nearly level flood plains and low terraces. The soils formed in calcareous highly stratified but predominantly coarse textured recent alluvium. Soils have calcareous, granular A horizons and sandy calcareous C horizons. They are well to somewhat excessively drained; slow or very slow runoff, rapid or very rapid permeability. These soils are used chiefly as native pastureland; however, they are tilled in some localities. There are an estimated 32 acres of these soils on the lease.

Ga-Gb-Goshen loam

Soils are along swales of uplands and terraces. They formed in medium textured colluvial-alluvial sediments from the adjacent slopes. For the most part, they are nearly level, but some are on gentle slopes. Typically, these soils have dark grayish-brown loam A horizons, grayish-brown silty clay loam B horizons, and pale brown silt loam C horizons. They are well drained, runoff is to moderate depending on slope; infiltration and permeability are moderate. Most of this soil is cultivated and summer-fallowed. Wheat and sorghum are the principal crops where dry farmed. Short, mid, and tall grasses are the native grass vegetation. There are an estimated 32 acres on the lease.

Renohill soil types

The Renohill soil types are found on gently sloping to rolling uplands and are underlain by weathered shale at depths of 20 to 40 inches. Soil reaction is moderately alkaline at 6 to 20 inches. Internal drainage is slow due to the clay subsoil. Productivity for native vegetation is medium, ranging from 750 to 1,800 pounds per acre dry weight. Agricultural use is limited due to shallow depth to bedrock and alkalinity. Present erosion condition is high. Erosion hazard increases to very severe if vegetation or protective cover is removed.

Ra-Rb-Renohill clay loam

Renohill clay loam occupies gently sloping to rolling uplands. The parent material is weathered shale of the Wasatch, Lance, and Fort Union formations. The clay loam surface horizon is 3 to 6 inches thick and has granular structure. The upper subsoil is clay to clay loam with prismatic and blocky structure. It normally contains no free calcium carbonate. The lower subsoil is clay loam and contains calcium carbonate. The clay loam substratum is calcareous extending to bedrock which occurs at depths of 20 to 40 inches. Soil reaction is normally neutral to moderately alkaline. The depth to calcareous material ranges from 6 to 20 inches. Internal drainage is slow. There are an estimated 224 acres of these soils on the lease.

Ra-Renohill clay

Similar to Renohill clay loam except with a clay textured surface.

Re-Renohill loam, rolling phase

This rolling phase differs from Renohill loam in topography, depth of soil, and degree of erosion. The topography is rolling to steep. The depth of bedrock ranges from less than 10 inches to 40 inches. Bedrock is exposed on some of the steeper slopes. Natural erosion has formed gullies in some areas. The parent material is weathered shale of the Wasatch, Lance, and Fort Union formations. The loam to sandy loam surface layer is usually 3 to 6 inches thick. The upper subsoil is clay loam to clay with blocky and prismatic structure. It normally contains no free calcium carbonate. The lower subsoil is clay loam and contains calcium carbonate. The clay loam substratum is calcareous. Soil reaction is normally neutral to moderately alkaline. The depth to calcareous material ranges from 6 to 20 inches. Internal drainage is slow. There are an estimated 232 acres of these soils on the lease.

Rf-Rough broken land

Rough, broken land consists of steep, eroded, strongly dissected areas along escarpments, steep-walled drainage channels, and rock outcrops. The parent material is interbedded shale, sandstone, and limestone. Small areas of shallow to deep soils are intermingled in rough, broken land. The density of vegetation is quite variable, ranging from bare areas or sparse vegetation on rock outcrops to dense stands on the deeper soils. The physical and chemical properties of the unit are very variable. There are an estimated 80 acres of this land type on the lease.

Ta-Tb Terry sandy loam

The Terry soil type occupies approximately 1,096 acres on moderately sloping to steep sidehill slopes. Depth to bedrock is 20 to 30 inches. Productivity for native vegetation is medium, yielding about 1,000 to 1,500 pounds per acre total dry matter. Present erosion is high due to steep slopes and fine sandy loam textures that are susceptible to wind and water erosion if protective cover is removed.

Ulm soils

The Ulm soil types are situated on rolling to steeply sloping uplands that are strongly dissected by gullies. Depth to bedrock ranges from 10 to 20 inches. Productivity is fair, yiedling approximately 500 to 1,500 pounds per acre total dry vegetative matter. Present erosion is high.

Ua-Ub-Ulm clay loam

This phase differs from Ulm loam in topography, texture, and depth of soil. The topography is rolling and the depth to interbedded sedimentary bedrock ranges from 10 to 20 inches. The steeper slopes have some rock outcrops. The surface horizon is granular clay loam about 6 inches thick. The subsoil is calcareous silty clay loam with prismatic structure. The subsoil normally becomes more loamy and friable with depth. Internal drainage is moderate to slow. Soil reaction normally ranges from neutral to moderately alkaline. There are an estimated 208 acres of these soils on the lease.

Uc-Ulm loam

Ulm loam occupies gently sloping to rolling uplands. The parent material is interbedded sandstone, shale, and loamstone. The surface horizon in friable loam 3 to 7 inches thick. The subsoil ranges from sandy clay loam to clay loam and has prismatic structure. The calcareous substratum ranges from sandy loam to clay loam and extends to weathered bedrock at depths of 20 to 40 inches. Soil reaction normally ranges from neutral to moderately alkaline.

Wa-Wibaux-Searing complex

This complex occupies rolling to hilly topography. It is characterized by numerous outcroppings or knolls of scoria which rise above the general surface of the land. Scoria is a reddish colored shaly material and clinker produced by the burning of underlying coal-beds. The very shallow to shallow Wibaux soils occur on the knolls and steep slopes. It includes knolls, mounds, and steep slopes where unweathered scoria is exposed. The texture is gravelly to very gravelly loam and sandy loam. The depth to bedrock is less than 10 to 20 inches.

Searing soil normally occurs between the knolls. The surface horizon is reddish-brown gravelly loam about five inches thick. The subsoil is reddish-brown gravelly clay loam and has blocky structure. The substratum is friable, calcareous gravelly loam. Bedrock generally occurs at an average depth of two feet. There are an estimated 224 acres of these soils on the lease.

These soils are highly eroded, unsuitable for agricultural use, and productivity is low for native vegetation.

Mineral Resources

Stratigraphic and structural relations

The Amax Coal Company's Federal coal leases in T. 47 and 48 N., R. 71 W. are on the gently dipping eastern flank of the Powder River Basin. The leases are in the Gillette coal field that was mapped by Dobbin and Barnett (U.S. Geological Survey 1927). Regional descriptions of the geology and coal are found in Volume I, pages I-158 to I-186 of FES 74-55. Information pertaining to the leases is from published geological reports and from the Amax Coal Company's mining and reclamation plans.

The lease area is on the boundary between the Fort Union Formation of Paleocene age and the overlying Wasatch Formation of Eocene age. The upper portion of the Fort Union Formation is the bedrock in the eastern part of the lease area. The Wyodak coal bed (designated the Roland-Smith coal bed by Amax Coal Company) at the top of the Fort Union Formation is usually not exposed at most places because it is masked by alluvium or by the red baked and fused rock, formed when the coal burned along the crop line sometime in the past. The Wyodak (Roland-Smith) coal bed on the lease area averages 70 feet in thickness and varies from 4,440 feet to 4,230 feet in elevation. Rock types that comprise the upper part of the Fort Union Formation are shown in the following stratigraphic section, located approximately 30 miles southeast of the Belle Ayr South Mine site, as reported by Dobbin and Barnett (U.S. Geological Survey 1927, p. 10).

Section of part of the Tongue River Member of the Fort Union Formation, between sec. 21, T. 43 N., R. 69 W., and Little Thunder Creek in sec. 34:

Clinker of Wyodak (Roland) coal bed (top of Tongue River Member). (Bed averages 70 feet thick on the Belle Ayr South lease area.)

	Ft.	In.
Shale, blue-gray, sandy	10	
Shale, carbonaceous, containing fossil leaves	6	
Coal		5
Shale, carbonaceous, and bone	1	9
Shale, blue-gray, carbonaceous	10	
Sandstone, gray, friable, with hard brown sandstone, concretions containing fossil leaves	5	
Shale, carbonaceous	1	4
Shale, sandy, and sandstone, friable with hard sandstone concretions	33	
Shale, dark, carbonaceous	9	
Shale, gray, sandy	7	
concretionary band at top	15	
Shale, dark bluish-gray, sandy with a few hard brown sandstone concretions	16	
Sandstone, yellowish-gray, friable, with a few bands of carbonaceous shale	38	
Shale, dark blue, with fossil leaves and with selenite crystals in upper part	7	
Shale, brown, carbonaceous, with fossil leaves and fragments of conifers		10
Shale, dark blue	1	2
Shale, bluish-gray, with brown sandstone concretions	12	6
Sandstone, yellowish gray, friable		11
Shale, bluish-gray		8
Shale, brown to black, with lenses of bright coal in upper part		2
Sandstone, yellowish, friable	6	
Shale, blue, with 1-foot lens of black carbonaceous shale near the middle	11	
Clay, yellow, sandy, with brown sandstone concretions near the base	5	
Shale, bluish-gray	11	
Shale, brown, carbonaceous	10	
Concealed	6	
Sandstone, gray, friable with 1-foot brown concretionary band at top	8	10
Largely covered but sandstone and shale exposed in places	108	—
	341	7

The remaining uneroded part of the Wasatch Formation is the overburden stripped at the Belle Ayr South Mine which ranges from 15 to 250 feet in thickness (Figure 12). Where it has not been altered to clinker in the lease area, the formation consists of gray, soft shale; grayish-white, yellow, and brown sandstone; and gray siltstone or sandy shale. Typical relationships of rock types are shown on the cross section in Figure 13.

Coal

The Wyodak (Roland-Smith) coal at the Belle Ayr South Mine is a single bed averaging 70 feet thick; the coal bed ranges from 0 to 80 feet in thickness on the lease (Figure 14). Coal is presently being produced from this bed on a Federal coal lease at this site, as well as at the Wyodak Mine just east of Gillette, Wyoming, and at the Antelope Mine in Converse County almost 60 miles south of Gillette.

Quality of coal

Based on analyses submitted by individual coal companies and from the Federal Government, the coal beds in the Fort Union and Wasatch Formations in eastern and southern parts of the Powder River Basin in Wyoming are subbituminous C in rank. The analyses of coal mined at the Belle Ayr South Mine is typical of the coal mined in the Gillette area.

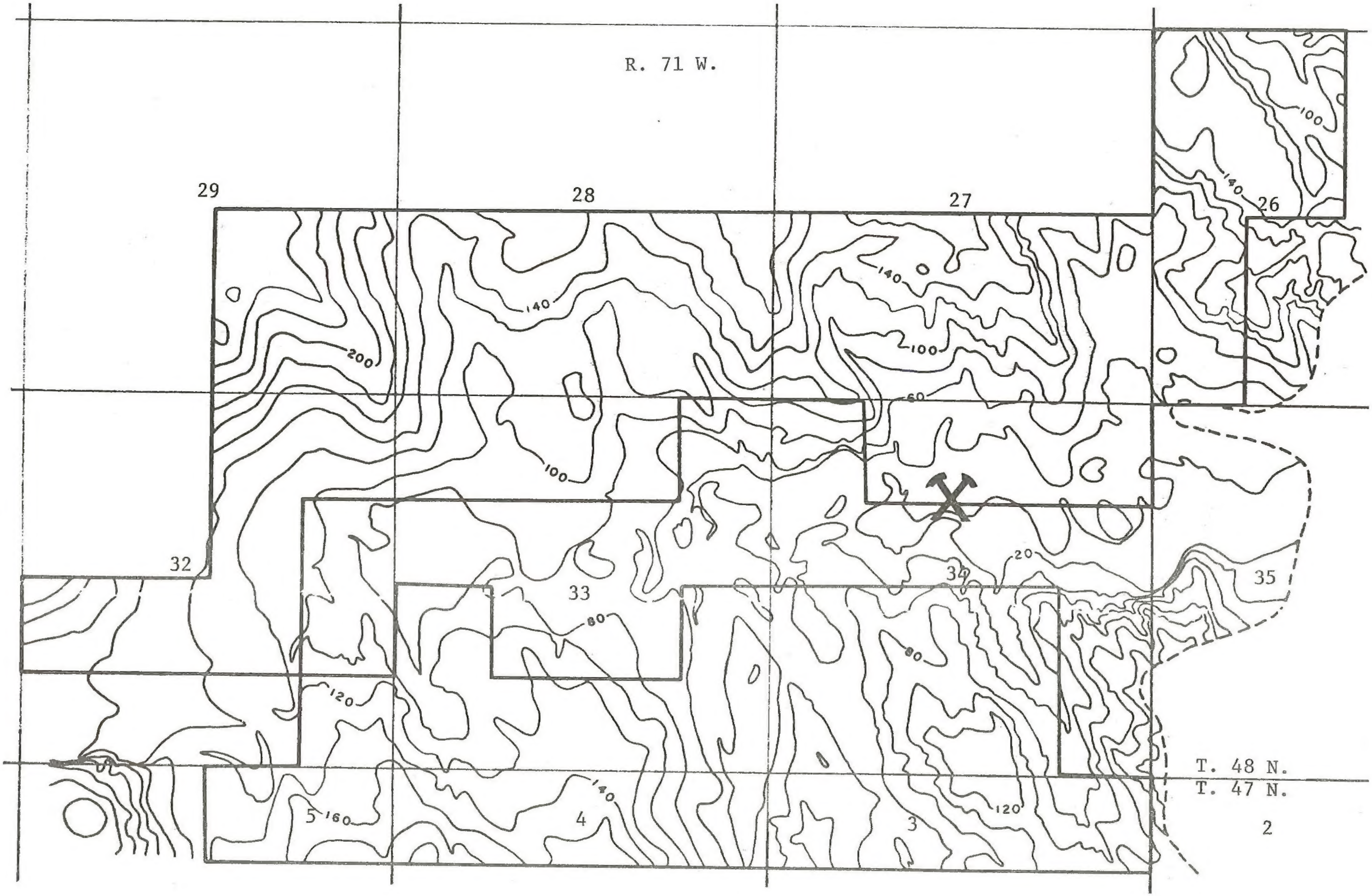

R. 71 W.
29
28
27
26
32
33
34
35
5
4
3
2
T. 48 N.
T. 47 N.
100
140
140
140
200
100
60
100
20
80
80
120
120
140
160

Figure 12

Overburden Thickness - Belle Ayr South Mine

⚒ Existing operation
Contour interval - 20 fe

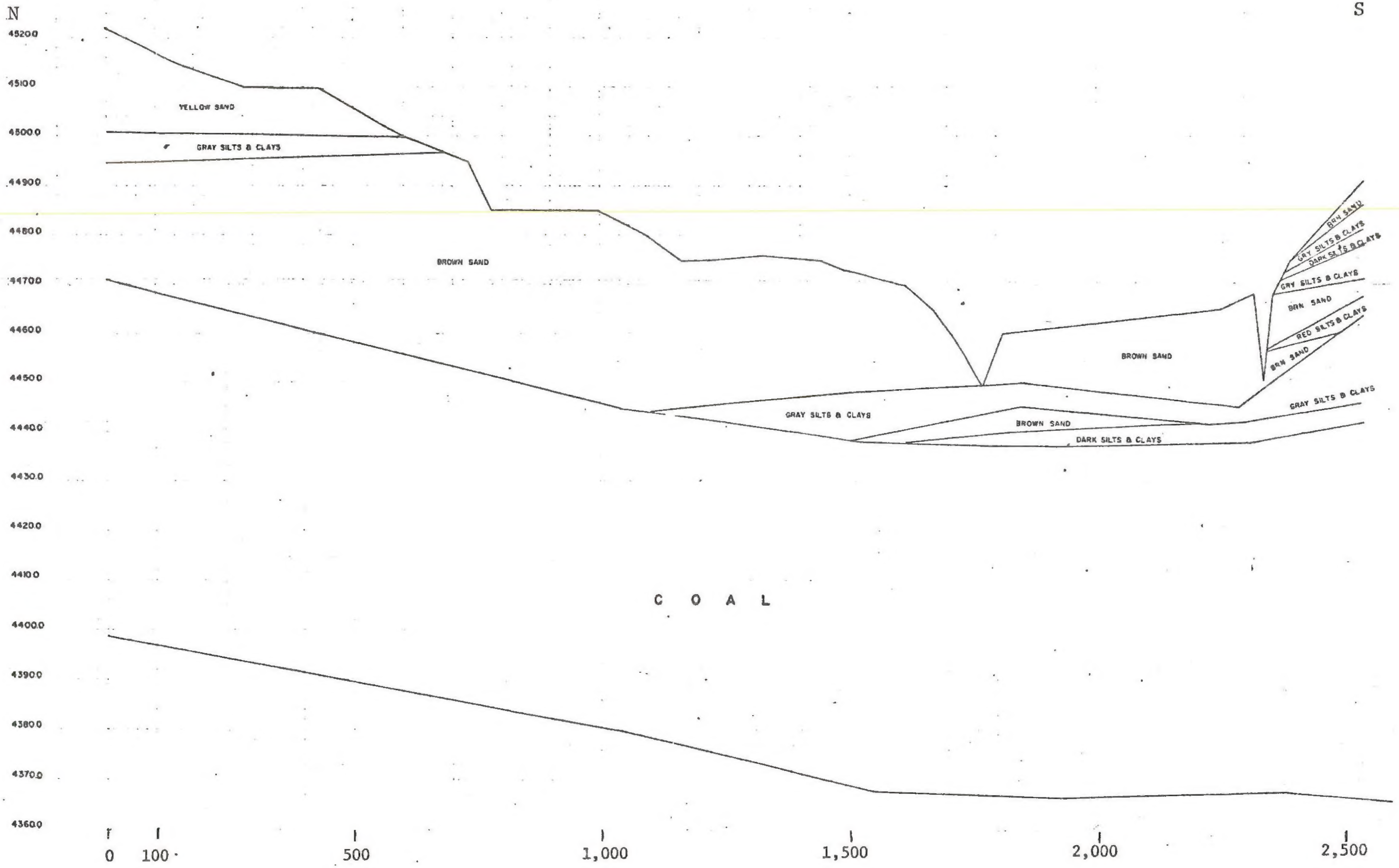

N
S
4520.0
4510.0
4500.0
4490.0
4480.0
4470.0
4460.0
4450.0
4440.0
4430.0
4420.0
4410.0
4400.0
4390.0
4380.0
4370.0
4360.0
YELLOW SAND
GRAY SILTS & CLAYS
BROWN SAND
BRN SAND
GRY SILTS & CLAYS
DARK SILTS & CLAYS
GRY SILTS & CLAYS
BRN SAND
RED SILTS & CLAYS
BRN SAND
BROWN SAND
GRAY SILTS & CLAYS
GRAY SILTS & CLAYS
BROWN SAND
DARK SILTS & CLAYS
COAL
0
100
500
1,000
1,500
2,000
2,500

Figure 13

Typical Mining Section - Belle Ayr South Mine

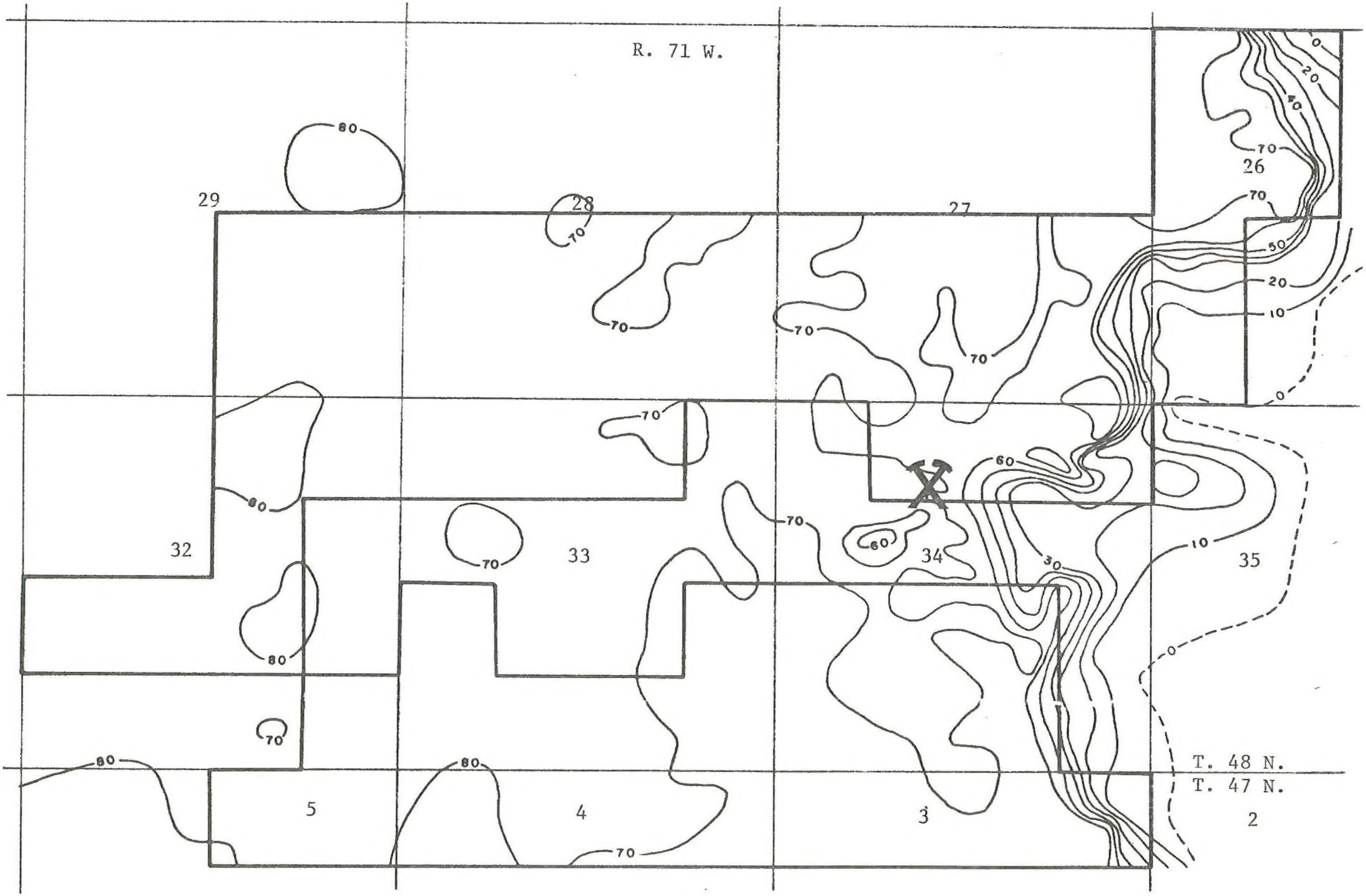

R. 71 W.
29
28
27
26
32
33
34
35
5
4
3
2
T. 48 N.
T. 47 N.
80
70
60
50
40
30
20
10
0

Figure 14
Coal Thickness
Belle Ayr South Mine

⚒ Existing operation
Contour interval - 10 fe

Representative coal analyses of the coal bed vary as follows:

Moisture	27-30%
Ash	4-6%
Sulphur	0.25-0.45%
Fixed Carbon	33-35%
Volatile Matter	31-33%
Btu	8200-8600

Proximate and ultimate analyses of a representative coal sample from the Belle Ayr South Mine are listed in Table 2. Major oxide composition of the ash of 8 coal samples analyzed by the U.S. Geological Survey is shown on Table 3. Trace elements in the coal may be transmitted to the atmosphere or concentrated in ash when coal is burned. The 8 coal samples from the study area that have been analyzed by the U.S.G.S. for trace element content (Tables 4 and 5) have shown no unusual or dangerous concentrations.

Table 2

Proximate, Ultimate, Btu and Sulphur Analyses of a Representative Coal Sample from the Belle Ayr South Mine. (All analyses except Btu in percent.)

Sample No.	D 160988
USBM Lab. No.	K-12883
Sample Interval	Tipple

	As Received	Moisture and Ash Free
Moisture	26.2	--
Volatile Matter	33.6	49.1
Fixed Carbon	34.9	50.9
Ash	5.3	--
Hydrogen	6.8	5.7
Carbon	50.7	74.0
Nitrogen	.7	1.1
Oxygen	35.9	18.3
Sulphur	.6	.9
Sulfate	.02	.04
Pyritic	.17	.25
Organic	.44	.64
Btu	8,820	12,880

Source: U.S. Bureau of Mines

Table 3

Major-Oxide Composition (in percent) of the Laboratory Ash of 8 Coal Samples from the Belle Ayr South Mine

Sample No.	Sample Interval (Ft)	Ash	SiO_2	Al_2O_3	Na_2O	K_2O	CaO	MgO	P_2O_5	Fe_2O_3	SO_3
D 160988	(Tipple)	6.64	26.	13.	1.19	0.3	21.	3.55	0.4	4.6	22.
D 163516	2.1	8.69	27.	12.	.98	.4	14.	2.60	1.4	14.	25.
D 163517	4.2	11.7	41.	19.	.65	.9	12.	1.80	1.7	2.8	15.
D 163518	5.	7.06	31.	16.	1.23	<.1	21.	3.40	.67	3.3	20.
D 163519	5.	6.42	31.	9.6	1.28	<.1	24.	3.80	<.05	3.8	17.
D 163520	5.	4.83	16.	11.	1.78	.7	29.	4.60	<.05	5.5	22.
D 163521	5.	4.38	15.	11.	1.83	.2	29.	4.80	<.05	4.3	25.
D 163522	(Tipple)	6.32	25.	12.	1.23	.3	22.	3.60	.40	4.1	23.

Source: U.S. Geological Survey

Table 4

Quantitative Determinations (in ppm) for 12 Trace Elements in 8 Samples of Coal from the Belle Ayr South Mine. Values for Cd, Cu, Li, Pb, and Zn are Calculated from Analyses on Ash of Coal.

Sample No.	Thickness of Sample Interval (Ft)	As	Cd	Cu	F	Hg	Li	Pb	Sb	Se	Th	U	Zn	Ash %
D 160988	(Tipple)	2	0.1	13.3	30	0.13	1.9	5.5	0.2	1.8	<1.5	0.6	6.8	6.64
D 163516	2.1	4	.1	12.0	90	.28	1.2	2.2	.4	2.2	<1.5	2.9	6.8	8.69
D 163517	4.2	3	.2	45	80	.13	4.4	5.3	.7	2.0	7.7	1.7	5.9	11.7
D 163518	5	3	.1	8.6	40	.13	2.0	<1.5	.3	.6	4.8	.4	7.6	7.06
D 163519	5	2	<.1	10.7	90	.10	1.2	1.9	.2	.3	<1.5	.4	4.6	6.42
D 163520	5	2	<.1	4.2	65	.08	< .5	<1.5	.2	.4	<1.5	< .3	2.7	4.83
D 163521	5	2	<.1	5.3	60	.06	.5	1.5	.1	.5	<1.5	.6	2.1	4.38
D 163522	(Tipple)	2	<.1	12.3	50	.09	1.4	2.2	.2	.9	<1.5	.9	4.4	6.32

Source: U.S. Geological Survey

Table 5

Semiquantitative Spectrographic Analyses (in ppm) for 19 Trace Elements in 8 Samples of Coal from the Belle Ayr South Mine. All values have been Calculated from Analyses on Ash of Coal.

Sample No.	Sample Interval (Ft)	B	Ba	Be	Co	Cr	Ga	La	Mn	Mo	Nb	Ni	Sc	Sn	Sr	Ti	V	Y	Yb	Zr
D 160988	(Tipple)	20	200	0.2	2.	5.	2.	10	20	0.5	1.5	5	2.	< 0.5	30	300	15	3.	0.3	10
D 163516	2.1	30	300	.7	3.	7.	3.	15	200	1.5	2.	10	5.	< .5	200	300	30	7.	.7	15
D 163517	4.2	20	300	.7	2.	10.	3.	20	30	1.	2.	3	7.	< .5	200	700	30	5.	.5	20
D 163518	5.	30	200	.3	1.5	5.	2.	10	20	.5	<1.5	3	2.	< .5	70	300	10	5.	.5	15
D 163519	5.	30	200	.2	1.	5.	1.	5	30	.5	1.5	3	2.	< .5	70	200	10	2.	.3	20
D 163520	5.	30	200	<.15	1.	1.5	1.	< 5	30	.3	<1.5	3	1.5	< .5	70	150	7	2.	.2	7
D 163521	5.	30	200	<.15	1.5	3.	1.	< 5	20	.7	<1.5	3	1.5	< .5	70	150	7	1.5	.15	10
D 163522	(Tipple)	20	200	.2	1.	5.	1.5	< 5	20	.7	1.5	3	3.	< .5	70	200	10	2.	.3	10

Source: U.S. Geological Survey

Quantity of the coal

The company proposed to mine 331 million tons of coal during the 25-year life of the mine. Company figures show that 2,200 acres of Federal coal and 690 acres of privately owned coal land will be mined. The coal bed averages 70 feet in thickness except where it has been eroded near the outcrop. About 252 million tons will be mined from the Federal land and 79 million tons from the privately owned coal lands. All of the available coal on the Federal lease will be mined except for the NW¼ of section 26.

Other minerals

Occurrences of minerals other than coal are not known on the lease block.

Clinker is abundantly distributed in the lease area and should be adequate to provide road material and ballast. Sand and gravel occur locally as thin lenses in alluvium on the intermittent streams.

Trace element content of the overburden

Amax Coal Company sampled overburden from 8 drill holes located on the Belle Ayr South property and spaced about one-half mile apart. The drill cuttings were divided into 74 separate samples for analysis of trace element content. In addition, FES 74-55 contains overburden trace element results from 24 samples taken in the Powder

River Basin. These samples, analyzed by the U.S. Geological Survey, are believed to be representative of the overburden in the region.

The Amax test results do not differ greatly from those considered normal for the region. Most of the differences can be attributed to the methods of analyses and the units used in reporting the results.

The trace element discussion from FES 74-55, and selected portions from the Amax study, are reproduced in Appendix E of this statement.

Water Resources

Ground water

Aquifers

Formations within about 4,200 feet of the surface in the vicinity of the Amax Belle Ayr South coal lease that contain aquifers are, in order of increasing depth below land surface, stream alluvium, Wasatch, Fort Union, Lance, and Fox Hills. Aquifers that are expected to be affected by mining operations are in the coal beds themselves and the overburden (Wasatch, and locally, stream alluvium) to be removed during mining operations.

Alluvium in the coal lease area consists of fine-grained sand with silt and clay beds and some lenses of gravel. The thickness of the alluvium is as much as 30 feet in the thickest part of the valley fill and thins to zero along the valley edges. The width of the valley ranges from about 400 feet to about 2,000 feet. The altitude of the water level in the alluvium is approximately the same as the water in the stream channel. A slight water level gradient toward the stream channel results in slightly higher water level altitudes at greater distances from the stream channel.

The Wasatch Formation consists of fine- to coarse-grained lenticular beds of sandstone and interbedded shale. At the Amax Belle Ayr South coal lease, the thickness of the Wasatch ranges from zero at its erosional edge to about 150 feet in the northwest part of the lease. The Wasatch is the overburden rock that overlies the coal to be mined.

No detailed information is available concerning the hydrologic characteristics of the formation. Ground water development has been for stock and domestic purposes; consequently, wells yield only a few gallons per minute--adequate for the intended needs.

Transmissivities are estimated at about 6,000 gal/day/ft but might be as high as 8,000 to 10,000 gal/day/ft for some of the better sorted sands. Transmissivities will vary from site to site because of the heterogeneous lithology of the formation, and may be no more than 1,000 to 2,000 gal/day/ft for the silt and poorly sorted sand parts of the formation.

Storage coefficients can be estimated by multiplying the thickness of the aquifer in feet times $10^{-6} ft^{-1}$. Thus for a thickness of 150 feet, the estimated storage coefficient would be 1.5×10^{-4}, and for a thickness of 50 feet, the estimated storage coefficient would be 0.5×10^{-4}. These estimates are only rule-of-thumb relationships, and no allowances are made for porosity or for compressibility of the aquifer. To improve these estimates, reliable aquifer tests would be needed.

Well depths range from about 100 to 200 feet. Water levels in wells range from about 50 to 150 feet below land surface. The Wasatch is the principal aquifer, in the vicinity of the coal lease, used as a source of water supply.

Limited sampling for analyses of chemical constituents show that dissolved solids in water in the Wasatch range from about 1,000 to 1,500 milligrams per litre.

The Fort Union Formation consists of about 2,000 feet of fine-grained sandstone and interbedded shale, carbonaceous shale, and coal beds. The Fort Union underlies the coal to be mined at the Amax Belle Ayr South coal lease.

Underlying the Fort Union Formation are about 1,500 feet of fine- to medium-grained sandstone and interbedded sandy shale and claystone called the Lance Formation and about 200 feet of fine- to medium-grained sandstone called the Fox Hills Sandstone. Water wells in the vicinity of the coal lease do not reach these deeper formations.

Water movement

Movement of ground water in the near-surface aquifers that will be affected by mining is eastward with a component toward Caballo Creek.

The mine pit is functioning as a sink for both the coal aquifer and the overburden at the Belle Ayr South Mine. A report by the Wyoming Water Resources Institute (WRRI) gives an average discharge of 150,000 gallons per day during the summer of 1974. The discharge from the pit has been decreasing since measurements started in March 1974, and at present totals about 100,000 gallons per day.

The flow of water in the coal is through fracture zones. An aquifer test in the coal by WRRI indicated a transmissivity of about 2,000 gal/day/ft.

Water use

Ground water in the vicinity of the lease and adjacent area that will be affected by mining operations is used for livestock and, to a lesser degree, for domestic purposes. The Wasatch formation, and to a lesser extent, the underlying coal seam are the principal sources of ground water.

Surface water

The lease area is drained by Caballo Creek and its tributaries. Caballo Creek originates from the west and flows in an easterly direction across the near center of the lease area (Figure 15). About 7.6 miles of Caballo Creek's main channel lies within the lease area, and about 18 miles of intervening ephermeral tributaries drain the lease area. The drainage pattern within the area is dendritic, indicating an absence of lithologic effects.

Caballo Creek is an intermittent stream with a drainage area of about 194 square miles upstream from the existing mine operation. The natural flow characteristics of the stream are significantly affected by numerous stock ponds located on small tributaries throughout its drainage. Storage by these structures results in some depletion of water through evaporation and seepage. The natural runoff is thus reduced by the structures. Streamflow occurs mainly from runoff of snowmelt or rainfall. The major portion of annual runoff occurs during the months of May, June, and July as a result of convective

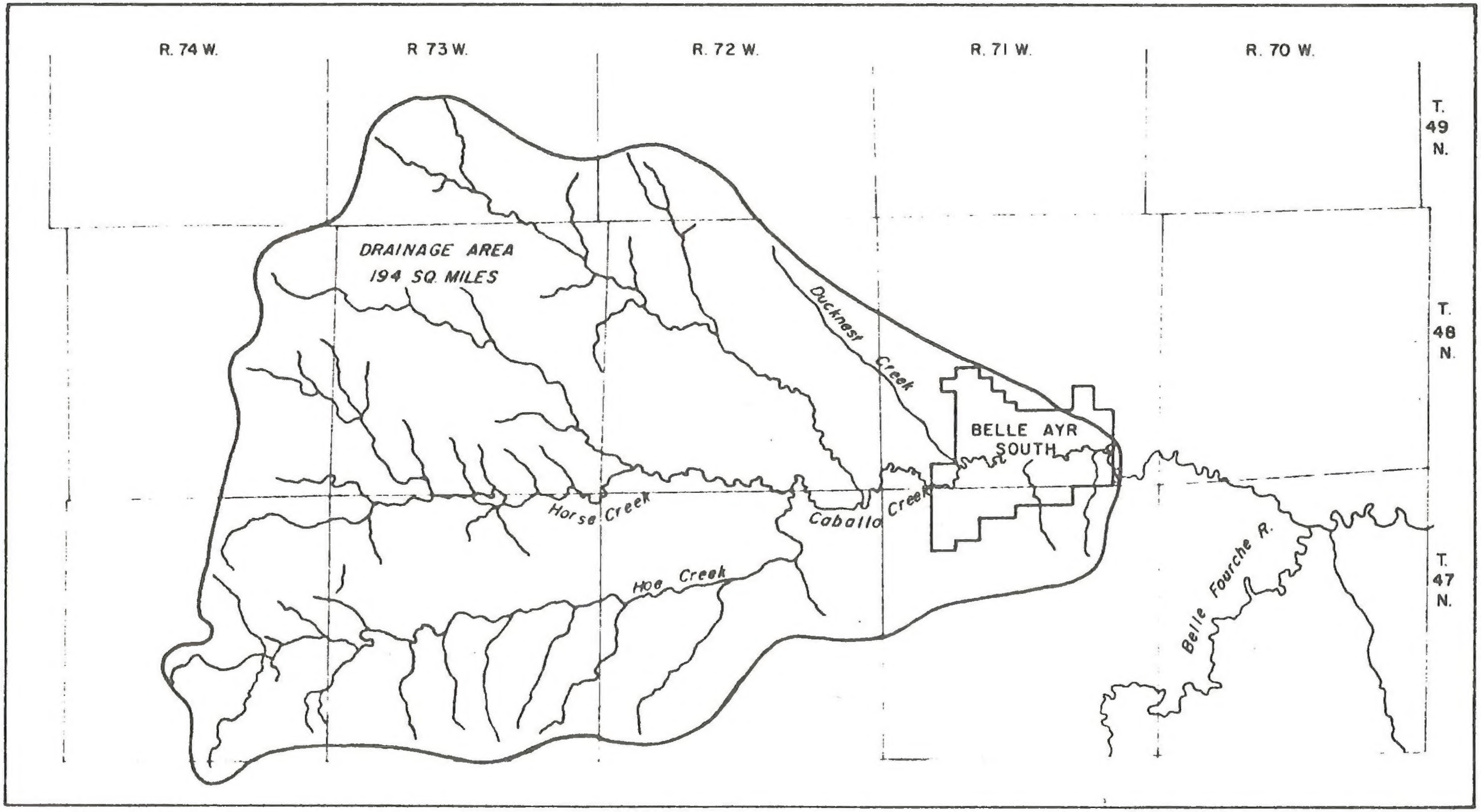

R. 74 W.
R 73 W.
R. 72 W.
R. 71 W.
R. 70 W.
T. 49 N.
T. 48 N.
T. 47 N.
DRAINAGE AREA
194 SQ. MILES
Ducknest Creek
BELLE AYR
SOUTH
Horse Creek
Caballo Creek
Hoe Creek
Belle Fourche R.

FIGURE 15

Belle Ayr South Drainage Basin

storms. Streamflow is highly variable and some of the smaller streams commonly have periods of a year or more with no flow. When flow does occur, it is often in the form of a flood. Although instantaneous flows of the flood peaks may be high, total runoff amounts are generally small due to the short duration and infrequent nature of the flows. Long-time residents of the general area say the highest flows occur when rain is preceded by hail, which beats the grass cover and soil so there is less retention of runoff when the rain begins.

Based upon its basin characteristics and channel geometry, Caballo Creek, at the existing mine site, is estimated to have flow characteristics as shown below (Lowham, in preparation).

Average annual runoff = 2,000 acre feet per year.

Annual peak flows (subscript designates average recurrence interval, in years, of the instantaneous discharge).

P_2 = 400 cubic feet per second

P_5 = 1,100 cubic feet per second

P_{10} = 1,800 cubic feet per second

P_{25} = 3,100 cubic feet per second

P_{50} = 4,300 cubic feet per second

P_{100} = 6,000 cubic feet per second

Records of gauging stations on other streams in the area show there is a high variation in year to year runoff values; thus, annual runoff and flood peaks can be expected to vary widely from the above averages.

Channel conditions in Caballo Creek are typical of many of the larger tributaries of the Belle Fourche drainage in which seepage of ground water has contributed to the formation of numerous potholes in the channels. During most of the year, evaporation equals or exceeds the seepage inflow; thus, although the channel may contain ponded water, there is no flow in the stream. The dissolved-solids concentration of the ponded water gradually increases to the point where aquatic vegetation cannot survive and, because the bed material of the channel has been loosened by the bouyant forces of ground water seepage, subsequent flow in the channel erodes material from these potholes.

The development and enlargement of these potholes plays an important part in the channel formation of the Caballo Creek drainage. As the base level of the main stream is lowered by this process, the channels of intervening tributaries must adjust to the lower base level. This adjustment takes place in the form of headcuts. As these headcuts progress up the tributaries, the entire watershed adjusts to the new base level and the average elevation is subsequently lowered. Due to the infrequent occurrence of flows, erosion proceeds very slowly over the years. Man made changes in the watershed, such as release of process water to the channel, decrease in vegetative cover, increase of channel or watershed slopes, etc., could accelerate the erosional process.

In general, streambeds of the area are composed of fine gravel, sand, silt, and clay; relative proportions of each vary locally depending on soil composition of the watershed.

The average slope of the streambed of Caballo Creek across the lease area is about 6 feet per mile. Minor tributaries on the lease area have slopes as high as 20 feet per mile. A few headcuts exist on these minor tributaries; however, the channels are generally grassed and have a stable appearance.

As with most plains-type streams, the quality of water in Caballo Creek is proportional to the magnitude of the flow. Concentration of suspended sediment, and turbidity, generally increase as flow increases; whereas, concentration of dissolved solids decreases as flow increases.

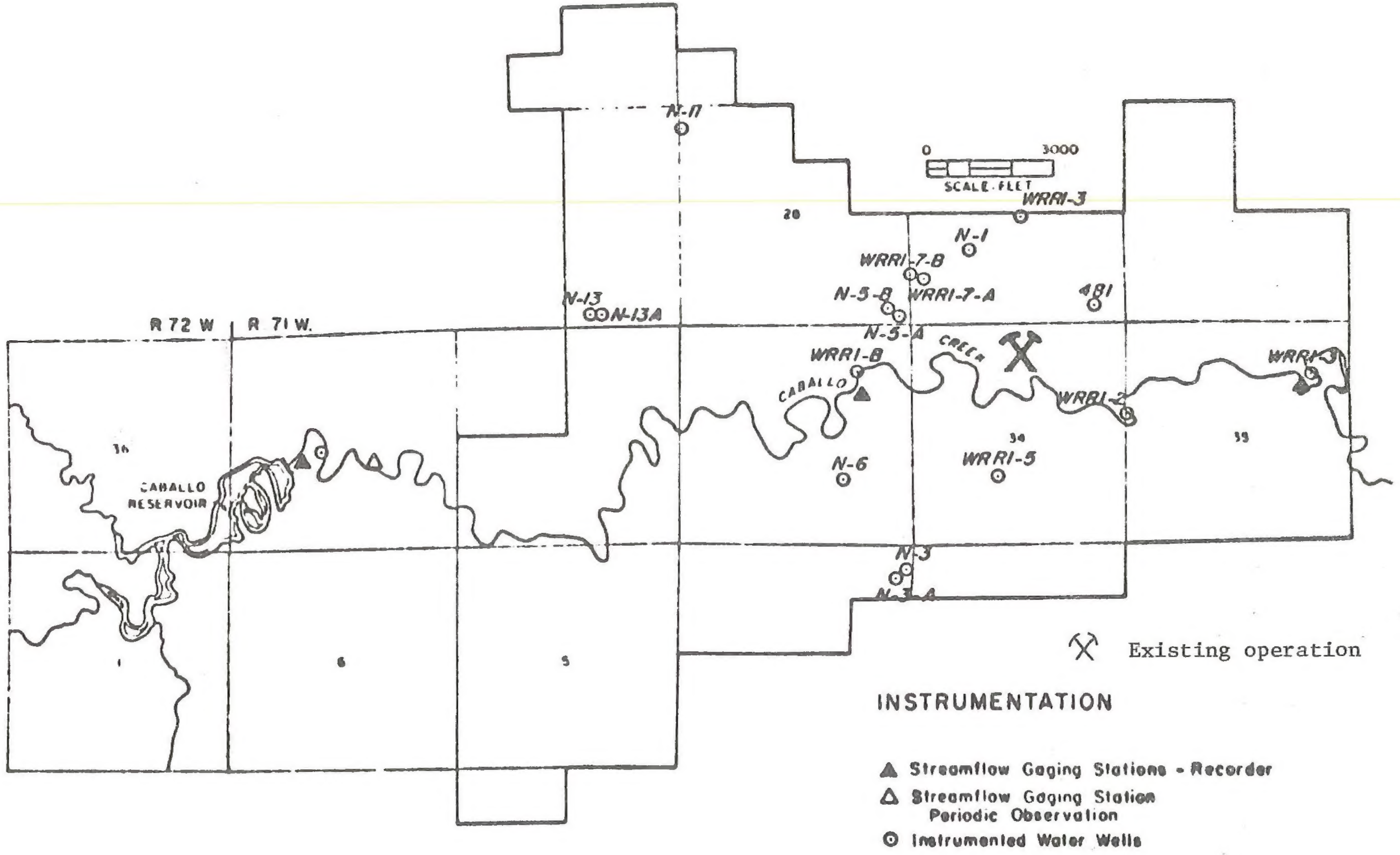
Sediment load of any stream is dependent upon (1) the ability of the watershed to supply sediment, and (2) the ability of the stream to transport the sediment. Portions of Caballo Creek's drainage are highly erodible, and an ample supply of sediment exists for transport. High sediment loads occur during high flows when the stream has large amounts of energy available for eroding and transporting sediment. Concentrations of suspended sediment can therefore vary from several milligrams per litre during low flows to over 100,000 milligrams per litre during high flows.

Chemical constituents of the streamflow are derived primarily from rocks and soil over and through which the waters of precipitation travel to reach the stream channel. Water dissolves chemical constituents from the soil and rocks. Dissolved-solids concentrations are usually highest during periods of low flow, when water reaches the stream only after a slow journey that often spans considerable distance. Low-flow runoff is therefore more concentrated with chemical constituents than high-flow because it is in contact with the rocks and soil for a longer period of time. Dissolved-solids concentrations of the stream can be expected to range from about 300 to over 1,000 milligrams per litre, depending on the magnitude and duration of the flow. During periods when the stream is not flowing, water trapped in potholes along the channel develops much higher dissolved-solids concentrations due to evaporation (McTernan, 1974).

The major use of surface water is consumption by domestic and wild animals. Caballo Creek reservoir, which is formed by an earthfill dam located in sec. 31, T. 48 N., R. 71 W. (Figure 16), is operated by the Wyoming Game and Fish Commission as a Public Fishing Area. The reservoir has a water right for storage of 868 acre feet; however, due to the variability of flows, the quantity and quality of the stored water is marginal as a fish habitat much of the time.

Three water rights existed for small storage structures on property now owned or leased by Amax. The largest of these rights was for 5.6 acre feet. These water rights have been purchased by Amax along with the surface rights. Figure 17 shows locations of surface and ground water rights in the vicinity of the mine site. Pertinent data regarding these water rights are included in Appendix F.

The Water Resources Research Institute (WRRI) of the University of Wyoming has conducted several hydrologic investigations in

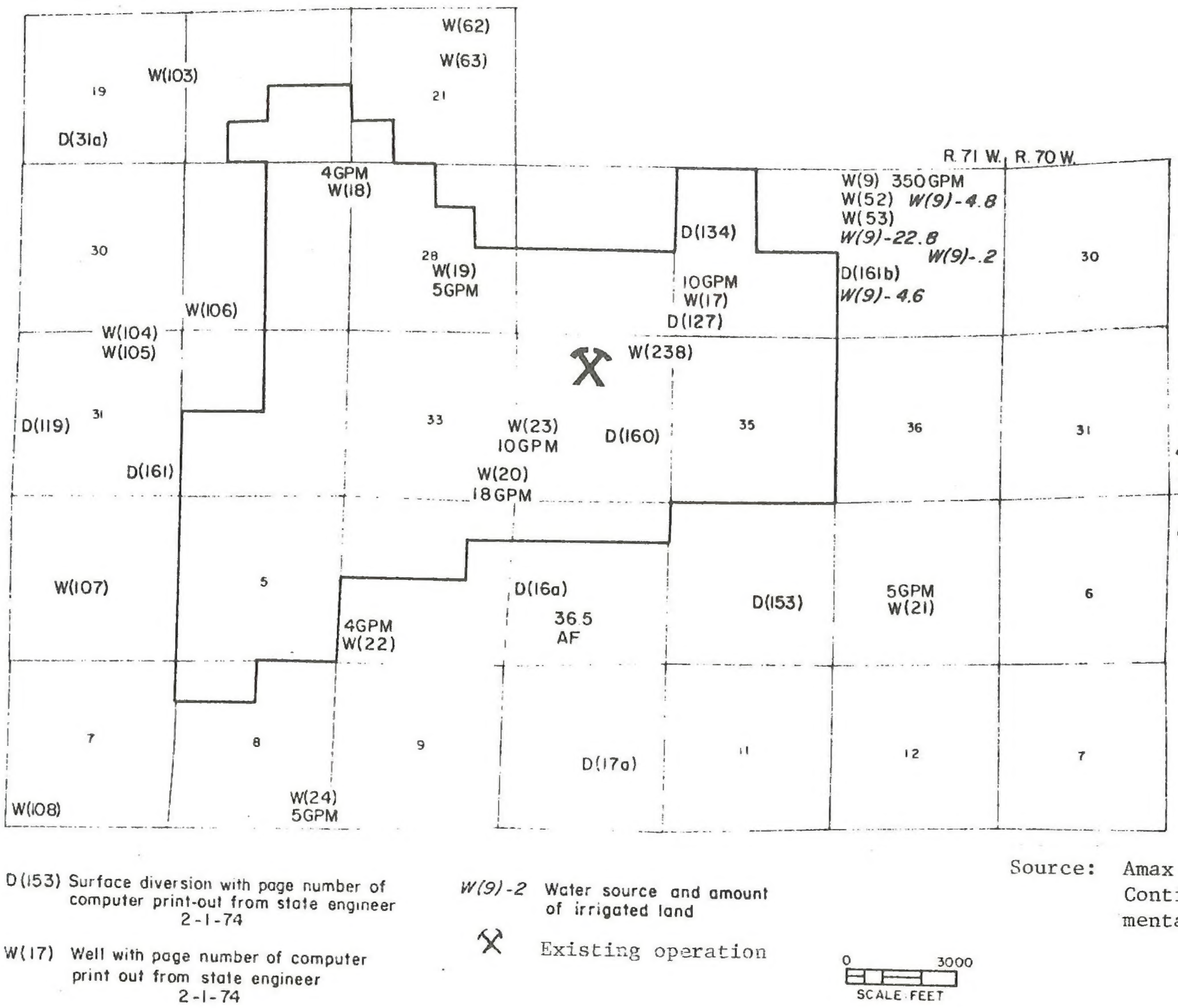


0
3000
SCALE-FEET
N-11
N-13
N-13A
R 72 W
R 71 W.
20
WRRI-3
N-1
WRRI-7-B
N-5-B
WRRI-7-A
481
N-5-A
CREEK
CABALLO
WRRI-B
WRRI-2
WRRI-3
36
CABALLO RESERVOIR
34
35
N-6
WRRI-5
T. 48 N
T. 49 N.
N-3
N-3-A
1
6
5
Existing operation
INSTRUMENTATION
▲ Streamflow Gaging Stations - Recorder
△ Streamflow Gaging Station Periodic Observation
⊙ Instrumented Water Wells

FIGURE 16

Hydrologic Monitoring Station Locations

BELLE AYR SOUTH MINE


W(62)
W(63)
W(103)
19
21
D(31a)
R. 71 W.
R. 70 W.
4GPM
W(18)
W(9) 350GPM
W(52) W(9)-4.8
W(53)
W(9)-22.8
W(9)-.2
D(134)
30
28
W(19)
5GPM
D(161b)
W(9)-4.6
30
10GPM
W(17)
D(127)
W(106)
W(104)
W(105)
W(238)
31
D(119)
33
W(23)
10GPM
D(160)
35
36
31
T.
48
N
D(161)
W(20)
18GPM
T.
47
N.
W(107)
5
D(16a)
36.5
AF
D(153)
5GPM
W(21)
6
4GPM
W(22)
7
8
9
D(17a)
11
12
7
W(108)
W(24)
5GPM
D(153) Surface diversion with page number of computer print-out from state engineer 2-1-74
W(17) Well with page number of computer print out from state engineer 2-1-74
W(9)-2 Water source and amount of irrigated land
Existing operation
0
3000
SCALE FEET

Source: Amax Coal Company Continuing Environ mental Studies

FIGURE 17
Surface and Ground Water Rights
BELLE AYR SOUTH MINE

cooperation with Amax Coal Company. A streamflow monitoring and sampling program has been implemented so that basic hydrologic relations and quantities of the area's streams can be accurately identified and monitored. Hydrologic data is being collected by WRRI at sites shown on Figure 16. Tables of streamflow data and results of infiltrometer tests made in the vicinity of the lease area are included in Appendix F.

Vegetation

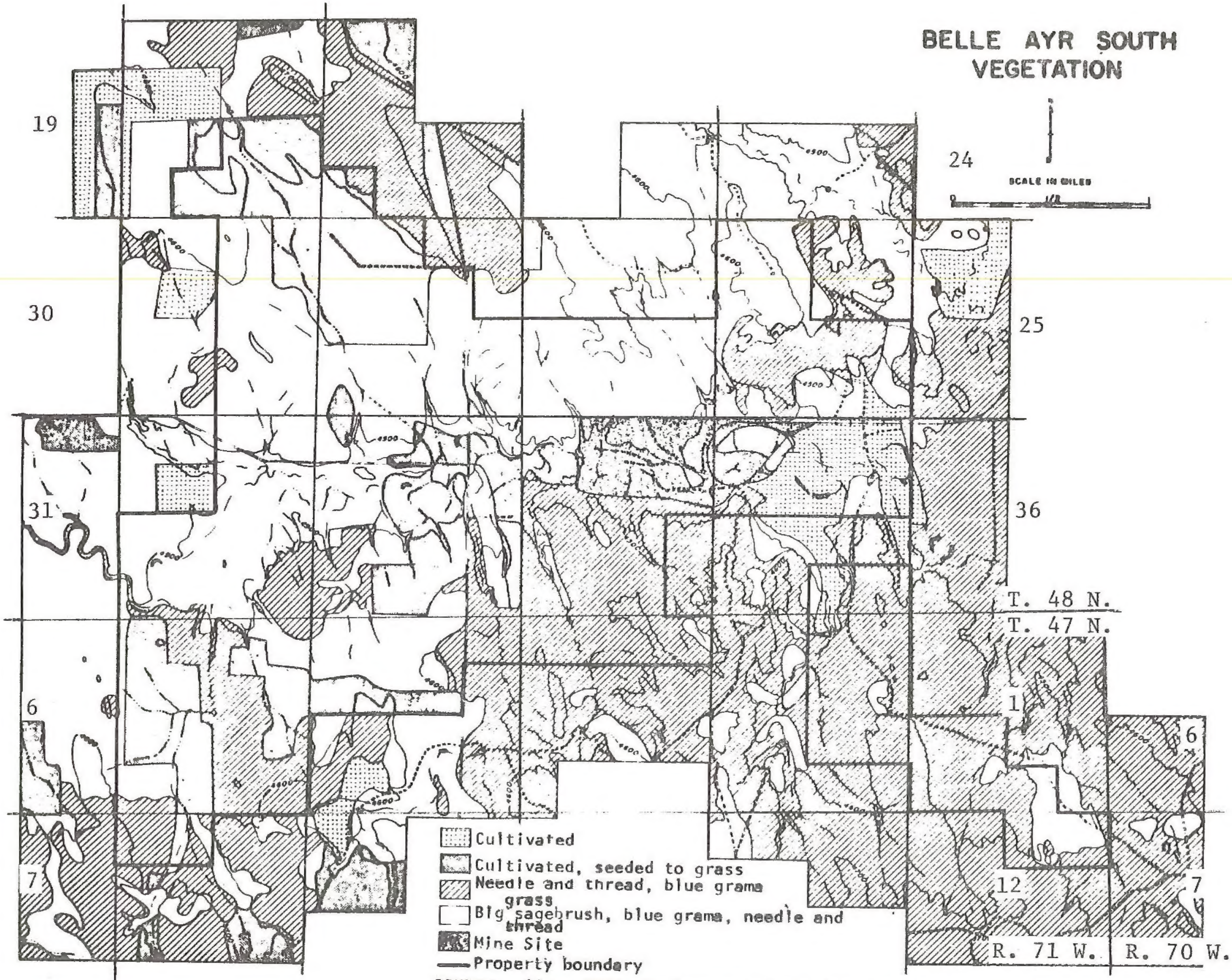
The native vegetation of the vicinity of the Belle Ayr South Mine is transitional between the short and mid-grass prairie types commonly found in the Northern Great Plains Region. Both short and mid-grasses are present with substantial proportions of big sagebrush.

The area covered by the mining plan is fairly homogeneous with the major vegetation differences existing between the native vegetation and substantial areas which have been cultivated for dry farming in the past and reseeded with grass (mostly crested wheatgrass). The preliminary vegetation mapping done by Amax delineated two native vegetation types, sagebrush and grassland. These types are described below and are shown on Figure 12.

Of the 2,890 acres covered by the mining plan, approximately 54 percent, or 1,570 acres, is occupied by sagebrush type vegetation. This vegetation type could be described as consisting mainly of big sagebrush, blue grama, needle and thread grass.

The grassland type vegetation occupies 728 acres or 25 percent of the mining plan area. This vegetation type is dominated by needle and thread grass, and blue grama grass.

The remainder of the mining plan area is occupied by the cultivated and seeded-to-grass (crested wheatgrass) areas (445 acres, 15 percent), and the existing Belle Ayr Mine site (147 acres, 6 percent). The existing mine site is in various stages of surface disturbance due to the mining activity. Some rehabilitation has been initiated but very little is located within the mining plan area.


BELLE AYR SOUTH
VEGETATION
SCALE IN MILES
0
1/2
19
30
31
6
7
24
25
36
1
12
6
7
T. 48 N.
T. 47 N.
R. 71 W.
R. 70 W.
Cultivated
Cultivated, seeded to grass
Needle and thread, blue grama grass
Big sagebrush, blue grama, needle and thread
Mine Site
Property boundary

SOURCE: After AMAX, Environmental Services Group, Vegetation Studies, Preliminary Data.

Figure 18

Vegetation Map - Belle Ayr South Mine

Within the sagebrush and grassland vegetation types, small areas of subirrigated vegetation exist along Caballo Creek. Small amounts of aquatic and riparian vegetation are present around the edges of perennial pools or pockets of water.

There are three shelter belt areas, two of which are located near the two ranch headquarters situated on the land and described in other sections. These shelter belt areas contain several well established species of trees commonly used for this purpose in the area.

Approximately 128 acres outside the mining plan area have been disturbed by activities directly related to the operation. A large portion of this area is occupied by the mine complex including buildings, silos, crushers, and related structures. Vegetation, where it exists, is primarily a mixture of the native species, disturbed area indicator plants such as weeds and sweetclover, and experimental plots of various types of vegetation under study to determine their suitability for rehabilitation purposes. Dry land winter wheat has been planted on an area inside the railroad loop to help stabilize the overburden which has been placed there.

An 18-mile railroad spur line has been constructed to the mine site from a point east of Gillette on the main line of the Burlington Northern Railroad. The railroad right-of-way averages 200 feet in width and occupies approximately 436 acres. Vegetation within this fenced right-of-way consists of a mixture of native species on the undisturbed sites and seeded vegetation on sites where surface disturbance was necessary.

Table 6 gives the common vegetation species found within the mining plan area.

The existing vegetation is considered to be of fair to good condition overall. The estimated ground cover from the modified "Parker 3 Step Method" used in Amax's range survey was 55-57 percent. This percentage is considered high compared to other estimates of similar lands in the vicinity but the difference is thought to be due to the variations in methods of estimation.

Table 6

Common vegetative species found on the Belle Ayr South mining plan area.

COMMON NAME	SCIENTIFIC NAME
Crested wheatgrass	Agropyron desertorum
Western wheatgrass	Agropyron smithii
Bluebunch wheatgrass	Agropyron spicatum
Red threeawn	Aristida longiseta
Blue grama grass	Bouteloua gracilis
Japanese chess	Bromus japonicas
Cheatgrass	Bromus tectorum
Prairie sandreed	Calamovilfa longifolia
Sixweeks fescue	Festuca octoflora
Prairie junegrass	Koelaria cristata
Canby bluegrass	Poa canbyi
Muttongrass	Poa fendleriana
Sandberg bluegrass	Poa secunda
Needle and thread grass	Stipa comata
Sedge	Carex eleocharis
Threadleaf sedge	Carex filifolia
Sedge	Carex heliophida
Western yarrow	Achillea lanulosa
Pussytoes	Antenaria dimorpha
Pussytoes	Antenaria rosea
Silver sagebrush	Artemisia cana
Fringed sagebrush	Artemisia frigida
Brown sagebrush	Artemisia pedatifida
Big sagebrush	Artemisia tridentata
Aster	Aster species
Hairy golden aster	Chrysopsis villosa
Winterfat	Eurotia lanata
Snakeweed	Gutierrezia sarothrae
Plains prickly pear	Opuntia polycantha
Crazyweed	Oxytropis lambertii
Phlox	Phlox hoodii
Wooly Indianwheat	Plantago purshii
Dandelion	Taraxacum officinale

Archaeological and Paleontological Values

Field examinations of the lands in the South Belle Ayr leasehold were made in 1971 and 1974 by personnel of the Montana University Statewide Archaeological Survey. Permission to conduct the surveys was obtained from the Wyoming State Archaeologist. The purpose of the examination was to search for, locate, and evaluate all remains of archaeological, paleontological, and historic materials on the lands to be mined.

Ten aboriginal sites were identifed in the area to be mined. Nine of these sites were located along Caballo Creek. A stone circle was located on one site. Some tools and projectile points were found on all of the sites. The pattern of occupation is similar to that in other areas in Campbell County, Wyoming. Small bands of Indians probably utilized the area for camping while hunting local game. None of the sites represented major campsites.

There were several random finds of fossil remains in the South Belle Ayr leasehold, but no specific sites of interest were found.

It was the conclusion of the examiners that there were no archaeological or paleontological sites in the area that warranted preservation measures or excavation. The Wyoming State Archeologist has reviewed the survey done by the Montana Statewide Archaeological Survey group and has accepted and concurred in the conclusions and recommendations of that group (Appendix G).

Within the Federal leasehold, there are no archaeological sites registered in the National Register of Historic Places.

Historical Values

The National Register of Historic Places, the State Historian, and local references and residents were consulted and no known significant sites, trails, or areas occur on this lease area. However, Indian tribes probably passed through and hunted buffalo and other game in the area. No campsite or other evidence of permanent habitation by these tribes are known on the lease.

The only structures with any historical interest in the lease area are a clinker homestead cabin, the remains of a nearby smaller building, and a large rock corral, all of which are located just southeast of the Belle Ayr Mine. The cabin was built in the early 1900's by Achiel DeMaegt. It is believed that he was killed while fighting in France during World War I. The coal company has recently started renovating this structure.

Aesthetics

Gently rolling uplands comprise about 70 percent of the lease area. The meandering Caballo Creek forms a green strip through the center of the proposed mine area with the more barren brown-colored rolling hills extending to the north and south. The coal burn line creates an irregular line of red-colored hills on the east edge of the lease.

Textures in the gently rolling uplands are smoother than those in the more irregular parts of the lease. The natural vegetation consisting of fairly evenly mixed sagebrush and native grasses gives a moderately roughened texture to the surface of the land. Textures in the severely eroded areas are generally rougher than the rolling uplands due to more scattered groupings of sagebrush and grass along with the rougher texture created by erosion. Various parts of the lease area have been cleared for cultivation at one time or another and have since revegetated with wild grasses and cactus. These areas have the smoothest textures displayed in the lease area due to the absence of the coarser sagebrush.

Colors within the area are muted tones of grays, greens, reds, and browns. The brightest colors occur in spring and early summer when the sage and grass vegetation is its greenest and wildflowers are in bloom. The most color contrast occurs in the wintertime when snowdrifts contrast with the darker tones of soils and winter vegetation.

The predominant color tones for most of the year are light browns and light grays as the seasons progress from spring through winter. Grays and light browns are displayed when soil is exposed by erosion or other disturbance. Redish tones appear in the clinker soil zones, mostly in the rougher eastern edge of the lease.

The landscape quality of the lease area is considered to be relatively low as compared to areas of rugged, dissected, and colorful mountains with much variety in form, line, color, and texture. However, on the microscale there is much variety in plants, insects, wildlife, and soils from one area of the lease to another.

Wildlife and Fish

Mammals

Big game:

Pronghorn antelope

This is the most abundant big game animal on the lease area. Amax biologists took an air census over 7,000 acres and found the density to be 59 animals per square mile. At this level, the area which will be disturbed by mining (under the mining plan, 2,890 acres) would support about 266 antelope.

The Amax South Mine is included in the Wyoming Game and Fish Department's Antelope Area 24, Thunder Basin. The 1973-74 estimated populations of area 24 was 2,700 animals. Thus the Amax properties support about 10 percent of the area's antelope, assuming fairly even distribution. The Amax properties are considered a winter concentration area surrounded by less important habitat.

Mule deer

The Amax South properties lie within Wyoming Game and Fish Department's Deer Management Area No. 21, Thunder Basin. The estimated 1973-74 winter population for the area was 1,800. Amax South properties support an estimated 50-plus mule deer. These animals are found primarily along Caballo Creek, its draws and bottomlands, but move to the uplands to feet when snow accumulates.

Other mammals:

Population density figures for lagomorphs and rodents have been estimated by Amax biologists. Using these figures, it can be estimated that Amax properties supported (1974) about 4,900 rodents and about 145 rabbits and hares.

In addition to the rodents and lagomorphs, a number of furbearers are found on the Amax property. Some of these are associated with riparian habitat, i.e. Caballo Creek, and include mink, muskrat, raccoon, and beaver. Others are more cosmopolitan, including skunks, badgers, bobcats, and coyotes. The skunks and badgers are most common; the other furbearers can be considered present but uncommon.

Birds

Upland game birds:

Mourning doves, sage grouse, and Hungarian (gray) partridges comprise the upland game population. Doves are migratory, but abundant in season. Gray partridges are scarce. Wyoming Game and Fish personnel estimate sage grouse numbers at 5 to 8 per square mile in this general area.

Three strutting grounds have been located (R. Williams, Wyoming Game and Fish Department, letter). These are located from

0.5 to 3 miles from present (August 1974) mine site. It appears that only one strutting ground is actually on Amax-controlled property. This one supported an estimated 10 males in 1974. One ground, on the east edge of Amax-controlled property, supported 20-30 male birds in 1974.

Raptors:

Population estimates have been made for some raptors on Amax property. Additional species may occur.

Several species are known to breed and nest on Amax land, including golden eagles, red-tailed hawks, marsh hawks, American kestrels, great-horned owls and ferruginous hawks.

Of particular interest is the definite location of a golden eagle nest on a steep bluff overlooking Caballo Creek at the west edge of the property, and the occurrence of bald eagles during the winter period.

Waterfowl and shorebirds:

Caballo Creek and scattered stockponds provide habitat for waterfowl. Amax biologists observed 33 breeding pairs of waterfowl in 1974. Mallards were the most common, comprising one third of this number.

Shorebirds frequent the same areas as the waterfowl. Nesting occurs among coots, killdeers, and spotted sandpipers. Killdeer are most common, nesting at densities of about 0.2 pair/acre.

Songbirds and others:

From data gathered by Amax biologists it can be estimated that the following approximate numbers of breeding pairs occupied Amax properties in 1974:

Horned larks	665
Vesper sparrows	376
Brewer's sparrow	290
Western meadowlark	230
Lark bunting	145
McCown's longspur	58
Rock wren	58

Reptiles and amphibians

Amax biologists have identified 13 species of reptiles and 6 species of amphibians as possibly occurring locally. Many or most would be closely associated with riparian habitat.

Fish

Caballo Creek is an ephemeral tributary of the Belle Fourche River and was intensively studied for aquatic life. Six species of fish were found to exist in a series of ponds. These include: flathead minnows, carp, white suckers, sand shiners, black bullheads, and green sunfish. Only the latter two are game fish.

Caballo Creek is insignificant as a fishery. Caballo Reservoir (off of the Amax property to the west) is a small body of water providing about 42 fisherman days use per year. It has been stocked since 1947 with largemouth bass and rainbow trout. Since

1956, about 17,000 bass and 11,000 trout have been planted. Other game species present include green sunfish and black bullheads.

Endangered and threatened species

Officially "endangered" species have not been observed on the Amax properties. The area is, however, within the general range of the black-footed ferret, the southern bald eagle, and the American peregrine falcon.

Appendix H of this statement contains selected tables from a wildlife study conducted by Amax Coal Company's Environmental Services group. These tables give a detailed listing of wildlife types which are associated with the mine site.

Recreation

Few recreational activities occur on this lease area.

Hunting antelope, deer, cottontail, jackrabbit, sage grouse, and waterfowl is the most common activity, with an estimated 50 visitor days use per year or less. As the surface is privately owned, hunting would be at the discretion of the landowner.

Other activities, such as sightseeing, artifact hunting, photography, and picnicing probably occur on the lease area in amounts of less than 20 visitor days per year.

Frequent opportunities to view antelope exist along Bishop road, a situation common to the region.

Agriculture

Ranching operations

Originally, two ranching operations were involved on the land covered by the mining plan. All lands to be mined under the present plan have been purchased and are currently under agricultural management by Meadowlark Farms, Inc., the agricultural subsidiary of Amax Coal Company. All the lands are under livestock grazing use at the present time. The Soil Conservation Service District Office at Gillette, Wyoming, indicates the land has an overall grazing capacity of 3 acres per AUM (animal unit month). A few small areas along the intermittent stream receive overflow water and subirrigation and would have a significantly higher productivity than the average. The land produces an estimated 1,017 AUM's (animal unit months) of forage annually.

Range improvements on the area to be mined consist of one livestock watering pond with two additional ponds nearby just off the mining area; one open shed with a set of corrals; one maintained ranch headquarters including a two bedroom house and several outbuildings and corrals; one set of unoccupied and non-maintained ranch buildings and approximately eleven miles of boundary and interior fences including county road right-of-way fences.

The land is traversed by approximately three miles of county road. One additional mile of county road has been relocated to the north boundary of the mining plan area to facilitate the existing mining operation. One large powerline, one small REA powerline and a telephone line traverse the land in a north-south direction adjacent to the county road. Branches from these lines have been extended to the mining area to service the mining operation.

The larger of the two ranch operations affected by the mining plan consisted of 7,000 acres and ran between 150 to 200 cows with some additional leased land. The previous landowner retained 1,120 acres in the vicinity which he still owns, although he has moved his main ranch operation to another locality. All the range improvements except approximately four miles of fence were on the land purchased by Amax as described above.

The second ranch operation involved 1,520 acres which was leased by the owner to a third party. The land produced sufficient forage for 50-60 animal units. Useable range improvements on the mining area consist of fences and a well.

Farming

No farming is currently being practiced on the land but about 15 percent has been cultivated in the past and seeded to grass. A few localized areas in the north half of Section 35 could be used as hay land as they have suitable topography and receive additional moisture due to their location near the intermittent stream.

Farming is not practiced extensively in the immediate vicinity due to low rainfall. However, Meadowlark Farms is conducting a farming operation on property adjacent to the mining operation on the east. Winter wheat is being grown successfully on overburden placed inside the railroad loop. Also barley and wheat are being grown on approximately 300 acres immediately to the east. Much of this land receives at least some flood and subirrigation.

Transportation Networks

State Highway 59 which connects Douglas and Gillette provides general access to the mining area. It is a narrow, two-lane, blacktop road. A 15-mile segment of the road from Gillette south was improved in 1972. In 1973, approximately eight miles of road was improved from Douglas north. Improvement consisted of widening the travel lanes and road shoulders and repaving.

County Highway T-7 runs north and south through the center of the lease. A secondary road connects this highway with State Highway 59.

Bishop road has been relocated along the northern boundary of the lease. This road is used by the ranchers living near the Belle Fourche River for access to the County Highway.

Socio-Economic Conditions

This operation comprises one portion of the large-scale development of coal resources in the Powder River Basin. As of 1970, about one-third (or 107,364 persons) of Wyoming's population resided in the Powder River Basin. Campbell County had 12.1 percent of the population, or 12,957 people. This represents an increase of about 121 percent from the 1960 figure due primarily to the oil boom in the region.

Employment in the coal mining industry accounted for about 0.7 percent of the population in 1970 in Campbell County. The unemployment rate was 2.6 percent.

The median ($11,303) and mean ($12,948) family incomes of Campbell County are the highest in the 8-county region considered in FES 74-55.

Selected tables reproduced from FES 74-55 concerning population, employment, income, housing, education, health services, police departments, and community attitudes are in Appendix I of this statement.

A detailed description of the existing socio-economic conditions to be found in Campbell and adjacent counties can be found in pages I-392 to I-458 in Chapter IV, Part I, of FES 74-55.

In January 1975, Amax Coal Company employed 72 permanent mine personnel at the Belle Ayr South mine. All of these employees live in or near the town of Gillette. Many of them live in trailer parks which were constructed during the oil boom and have been recently reactivated.

CHAPTER III

PROBABLE IMPACT OF PROPOSED ACTION

Air Quality

The company proposed to mine 331 million tons of coal over a 25-year period. They will strip 2,890 acres to mine this tonnage. The company started mining coal in 1973. The continued removal of vegetation and disturbance of topsoil and overburden will expose soil and parent material to wind action which is frequently quite strong. Soil particles will be lifted by the wind and carried into the atmosphere, causing a reduction in air quality and reducing visibility during periods of high wind. Coal dust from crushers, trucks, coal piles, and loading operations will also pollute the air during the frequent windy periods.

Emissions from machinery, vehicles, and trains will add particulate matter and odor to the air on and adjacent to the mine site. Increased populations associated with the mine and its employees will generate increased vehicle traffic. Increased traffic and commuting to work will add additional emissions to the air, causing a further decrease in air quality. This operation will be one segment of the larger development of the Eastern Powder River Basin and as such will contribute to the cumulative regional impacts on air quality as discussed in Volume II, part I of FES 74-55 (pages I-461 to I-468). The movement of coal by rail from the mine will contribute a portion of the estimated cumulative emissions from locomotives in the study area as summarized in Table 7.

Year	Coal Hauled		Diesel Fuel per day-1000 gals.**	Estimated Cumulative Emissions-tons per year***				
	Unit Trains/year*	Million tons/year		Particulates	Sulphur Dioxide	Nitrogen Oxides	Carbon Monoxide	Hydro-Carbons
1980	4,364	48	58.3	266	606	3,937	1,383	1,000
1985	6,182	68	84.1	384	875	5,679	1,995	1,443
1990	8,455	93	112.5	513	1,170	7,597	2,669	1,930

*Loaded trains. Same number of empty trains would be required.
**Fuel requirements include loaded and empty trains.
***Assumed to operate 365 days per year. Also includes loaded and empty trains.

Source: Environmental Protection Agency, Compilation of Air Pollutant Emission Factors, Table 3.2.2-1 EPA Publication No. AP-42, April 1973.

Table 7

Estimated Cumulative Emissions from Locomotives in the Study Area

With increased mining more coal will be exposed to the atmosphere, increasing the chance of accidental coal fires. Any fires will add particulate matter and other potentially toxic chemicals to the atmosphere. Increased train traffic and people on the area also increase the possibility of wild fire occurrences. These would cause a temporary lowering of air quality with the addition of smoke and particles to the air.

Inversion periods of two-day duration normally occur 15 times a year. These inversions will trap emissions. During inversion periods. respiratory conditions could be aggravated. During normal weather conditions, these pollutants will be carried downwind to the east and southeast, dispersed, and diluted before reaching any population centers. Projected particulate dust and water vapor emissions are not considered to be large enough to change atmospheric solar-energy exchange processes.

Reduction in air quality has already begun, will rise to a maximum in 1977, and level off thereafter during the 25-year period covered by the mining plan. The total area disturbed by new construction is too small to significantly affect the local climate. The mine operation may cause a slight increase in annual precipitation downwind from the operation because of the slight increase in atmospheric moisture content and the availability of particles to condense upon.

Microclimate

Temperature modifications in the microclimate of the asphalted and cemented areas are expected. Asphalt and cement have much greater thermal conductivities than soil. Thus, ambient air temperatures directly over these areas may be 2 to 3 degrees warmer than the surrounding air environment during the day and early nocturnal hours. Slight decreases in evapotranspiration within the mocroclimate zone of the paved areas would also be noticed since some vegetation and soil would be replaced by pavement. Minor impacts upon the microclimate are expected in the form of slight humidity and temperature changes from the modification of the land surface. The microclimate temperature ranges will tend to increase slightly, due to the more rapid radiational heating and cooling of paved or barren earth surfaces as compared to the surrounding natural grassy areas. These temperature changes would cause evapotranspiration to increase during the day and the incidence of dew and condensation to increase at night.

Topography

The coal bed at the Belle Ayr South Mine, excluding thin coal at the burn line, averages 70 feet in thickness. Overburden thickness ranges from about 15 feet to 225 feet. After mining, the decrease in surface altitude over the lease area will range from a maximum of 67 feet to a minimum of 25 feet. The average lowering of land surface for the entire area to be mined will be about 48 feet. The maximum decrease in altitude will occur in the areas which have thick coal in relation to thin overburden.

When the area has been mined and reclaimed, the surface in some areas will probably be left nearly level instead of in its present form. Any cliff-like or abrupt topographic breaks now present on the land will be eliminated. It will not be possible to return the rugged topography on the southern and eastern part of the lease to its original form.

Soils

The soils occurring within the Amax South lease area are moderately to highly susceptible to wind and water erosion if the vegetation is removed and topsoil disturbed. The revegetation capabilities are poor due to high alkaline or sodium concentrations. Although present native vegetation is sparse, it is tolerant to the salt concentrations and able to provide a protective plant cover against wind and water erosion. As these soils are derived from shale parent materials, they have a moderate to high shrink/swell potential and are highly susceptible to compaction. These two factors, coupled with low infiltration and permeability rates, increase the hazards for erosion, revegetation, water runoff, and flooding, and limit their suitability for reservoirs, topsoil for disturbed areas, road fill material, and other construction uses.

Mining of the area will result in destruction and mixing together of all existing soil types and their horizons on 2,890 acres. Soils have already been disturbed on about 147 acres within the mining area in connection with the existing operation.

In addition to the topsoil which will be disturbed by mining, the lower soil horizons will be removed as part of the approximately 450 million cubic yards of overburden excavated during the life of the mine. This will result in complete destruction of the soil stratification and change its existing characteristics. Even under the best of conditions there is the possibility that the mixing of horizons or soil strata could result in having material on the surface which may be toxic to plant growth, as well as exposing undesirable parent material to weathering processes. At the completion of mining, the soil structure and its properties will be completely different from that which exists at the present time.

These disturbances will result in fine-grained material being exposed to wind and water actions until revegetation is completed. Soil permeability and infiltration rates may be reduced, thereby increasing runoff, soil erosion and sedimentation. Wind action is almost constant over the area and will cause fines, silt and clay particles, to be lifted into the atmosphere. Coarse material such as sand will be moved along the ground surface, reducing air quality and adding to soil loss. As all physical, chemical, and biological systems will be disrupted to an unknown degree, the overall result could be the general lowering of soil productivity in the areas disturbed.

Alteration of small channels and watersheds will affect the downstream portions of these creeks and adjoining land areas. Channelizing stream courses and releasing production waters, including mine drainage, may cause increased flow velocities, which could result in accelerated erosion of stream beds and banks. This would increase the amount of soil loss in the immediate area as well as along the downstream channels. With alteration of stream channels and upper watershed areas, some areas may be deprived of normal soil moisture, thereby affecting soil productivity and vegetative growth.

The construction of mine facilities on approximately 128 acres has already disturbed and removed the soil from productivity for the duration of their existence. A railroad spur has been constructed for coal transportation which occupies approximately 436 acres. This land is also removed from production for as long as the spur exists.

Mineral Resources

The removal and consumption of an estimated 331 million tons of coal from this area over the period of time covered by the mining plan will result in depletion of a nonrenewable energy source. The coal produced will be exported to utility plants in the midwest for production of electrical energy.

The strip mining of thick coal beds by the proposed mining methods will result in the recovery of close to 95 percent of the coal. This is the most efficient method of mining coal today.

The coal bed has burned near the outcrop of the Belle Ayr South Mine and created large deposits of clinker. Some of this clinker will be used to construct roads and for other purposes in the mining operation. Very little of it will be disturbed by the mining and most of the deposits will still be available for use after the mine is closed.

Water Resources

Ground water

During mining and reclamation

Mining of a total of 331 million tons of coal over the life of the project from 1973 to 1997 and disturbance of 2,890 acres of overburden will destroy present aquifers within the coal and overburden. Breaching of these aquifers by mining will intercept present local flow and drain the water into the pits. Local dewatering as a result of mining operations and other withdrawals for water supply will lower water levels to the base of the coal in the pit. Wells that derive water from shallow aquifers within the area of increased drawdown could be affected. Springs and seeps in the area of influence may also dry up. Reduction in water levels could impact agricultural use and wildlife populations.

Adequate aquifer test data from the coal and the overburden deposits do not exist in this area. Such tests, or the monitoring of water levels, in properly spaced observation wells during actual mine dewatering operations would be necessary to determine accurately the magnitude and extent of the effect of mine dewatering upon water levels in nearby areas. From limited data obtained from mine dewatering operations now in progress in the Gillette area, an estimation of the effects of dewatering of the Belle Ayr South Mine on nearby water levels is possible. It is estimated that the area of influence caused from mine dewatering could extend outward as much as two miles from the active mining area. Most of the effects will be west of the mining operations. Within the area of influence caused by dewatering, water levels will be lowered the most nearest to the mine and the effect will decrease with distance from the mine area.

The removal of considerable overburden could have an effect on the artesian pressure in the underlying aquifers. Reduced overburden (removed load) could cause a movement of water upward in the underlying aquifers because the artesian pressure would respond to the reduced load and the potentiometric surface (pressure) would rise. Thus, the removed overburden could also result in an increase in water discharge into the mine pit. The data available is too scant to determine whether such impacts will occur, or to estimate the likelihood of occurrence.

The area to be mined is a ground water discharge area. Recharge to the deposits to be disrupted by mining occurs west of the lease.

After reclamation

Pre-mining recharge and discharge conditions in a mined area will not be fully restored by reclamation because of the disruption of the natural aquifers. To the extent that depressions on the reclaimed surface are below the re-established water table, discharge will occur and the total amount may be greater than that which existed before mining, but where the new surface is above the new water table, local recharge will be enhanced.

During the first few years after reclamation, the reclaimed fill may be more permeable than the original deposits. As compaction and consolidation take place, however, the reclaimed deposits are expected to become less permeable than the original deposits because the backfill material will be more heterogeneous than before disturbance. Also, any secondary permeability that was present in the original deposits, such as fracture or fissure patterns, will not exist when the overburden is replaced.

Because the reclaimed fill area will, in time, be less permeable than the undisturbed adjacent deposits, ground water flow paths will diverge, down gradient, around the mined area, or possibly, some mounding and increased discharge will occur up gradient from the mined area. Where local recharge occurred before mining, destruction of existing drainage patterns may, for a time, increase recharge by ponding water in the fill area. As drainage is reestablished, recharge will be less because of the lower permeability.

The reduction of permeability may result in less water flowing into the aquifer and increase surface runoff which could increase erosion and sedimentation. Although the overall altitude of the land could be reduced, this could result in less runoff in low areas where ponding may occur.

Water quality

Ground water

Since the active mining area will be a point of discharge, reduction of quality of water in the aquifers will not occur while mining is taking place. After spoils have been returned to the pit, leaching by infiltration of water will occur and the chemical quality of the water in the aquifers could be changed somewhat. This water would eventually move down gradient toward discharge points along Caballo Creek. The discharge of this water could result in lowering water quality in this stream.

Acid waters resulting from mining are not expected because the natural water of the area generally has a pH well above 7 and because of the small amounts of pyrite and other sulfide ore present in the coal.

Surface water

During the mining operation, the existing drainage pattern of the lease area will be disrupted. Caballo Creek will be diverted from its natural channel to a course around the perimeter of the pit. An 0.8 mile diversion has already been constructed around the existing operation. Channelization and diversion could cause accelerated erosion of intervening tributaries as they adjust to a new base level of the main stream.

The water supply of Caballo Creek will be insignificantly affected by the mining operation. Some seepage loss of streamflow will occur from the diverted stream to the pit; however, due to the infrequent occurrence of flows, this seepage will amount to a minor part of the total runoff. Peak flows will be unaffected unless the diversion washes out and allows the pit to fill with water.

The three small water storage structures existing on the property owned or leased by Amax will be destroyed during the mining operation. The water rights on these structures will remain valid, provided they are reconstructed within a period of five years.

An assessment of bacteriological and chemical constituents has been made on waters directly influenced by the mining operation (McTernan, 1974). Special emphasis was directed toward determining the potential for acid mine drainage formation, which is a problem often associated with coal mining activities in other areas of the country. No evidence could be found that the bacterial ecology of the area had been adversely affected.

The mining plan provides for any seepage or precipitation to the pit to be used for dust control, with excess water to be discharged to Caballo Creek. A small pond has been constructed near the mine pit to temporarily store flows that are pumped from the pit. Seepage to the pit presently amounts to about 100,000 gallons per day (0.3 acre feet per day). The seepage is being totally consumed for dust control. As the pit size is increased, the seepage amount will also increase. In the case that the amount of seepage is more than can be used for dust control and other mine uses, it is in the mining plan to release the excess water to Caballo Creek. This release would require a discharge permit as required by the Wyoming Environmental Quality Act of 1973. The amount of seepage presently encountered could be released without causing adverse affects to the downstream channel form; 100,000 gallons per day would be lost within a few miles through evaporation, transpiration, and seepage.

The reclamation plan shows two alternatives for treatment of the final land form. The first alternative provides for a return of the area to its original land use and condition, with the exception that the relief would be subdued to account for the extraction of the coal. The channel of Caballo Creek would be returned to its original location. This plan would cause no adverse impacts to the surface drainage or water resources of the area, provided the slopes of the stream and its tributaries are blended in with the adjacent land area in such a way as to minimize erosion.

The second alternative proposed by the coal company is to reclaim the area in such a manner as to create a 930 acre lake capable of retaining 17,750 acre feet of water. A proposal is also submitted that a dam could be constructed to increase the storage to a maximum of 52,303 acre feet. The alternative of a lake development does not appear to be feasible for several reasons. First, the natural runoff of Caballo Creek upstream from the lease area is estimated to be about 2,000 acre feet per year. Annual evaporation in this area is estimated to be about 36 inches; thus, a 930 acre area could evaporate most of the total inflow. Evaporative concentration of the dissolved solids, plus warm water temperatures would make the lake marginal as a fish habitat during much of the time.

Secondly, the surface waters of Caballo Creek are governed by the Belle Fourche River Compact, which specifically states that "no reservoir built solely to use the water allocated to Wyoming shall have a capacity in excess of 1,000 acre feet." Even if negotiations could be made to allow construction of a lake, the surface waters allocated to Wyoming are fully appropriated and very little, if any, excess water exists.

The construction of a lake area would further cause problems of erosion in the upstream drainage. Because the lake level would be at a low elevation during much of the time, Caballo Creek would have a steep inflow channel, which could cause headcutting and (or) down-cutting upstream. The watershed upstream from the reservoir could therefore be affected as it would have to adjust to a new base level of the main stream.

Vegetation

Approximately 147 acres is in the existing mine site area where the native vegetation has been largely destroyed. Also, 128 acres have been impacted by ancillary activities outside the mining plan area, with nearly complete destruction of native vegetation. This area of previous impact can be expected to receive relatively slight additional impact from the continuation of the proposed mining.

During the progression of the 25 year mining plan, existing vegetation will be destroyed on 2,743 additional acres as the mining proceeds across the area in the plan. The vegetative types are as follows: 1,570 acres of sagebrush, 728 acres of grassland, and 445 acres of cultivated areas seeded to crested wheatgrass. The plan indicates that mining will involve mostly the sagebrush type in the northern portion until 1983 when the mining operation will move to the southern portion, which consists mostly of grassland. At full production by around 1977 from 126 to 128 acres will be mined each year.

Relocation of the county road around the mined area and relocation of the powerlines and telephone lines could destroy vegetation on another 85 acres, depending upon the location. The 436 acres already occupied by the railroad spur can be expected to receive relatively little additional impact with respect to vegetation. The use of herbicides for maintenance of the right-of-way would destroy target vegetation inside the sprayed area as well as damaging non-target species and other vegetation nearby by drifting. Coal trains may cause fires which would be harmful to vegetation both on and adjacent to the right-of-way.

Haul road and overburden removal dust, and fugitive coal dust from mining, blasting, transporting, processing, and loading unit trains will be deposited on vegetation adjacent to the mine. Toxic chemicals, if present, in the deposited dust may damage vegetation when wetted by dew and light rain. Dust-covered and damaged vegetation would be less palatable and possibly toxic to livestock and wildlife.

A major problem associated with mining is the difficulty of reestablishing vegetation on the mined areas. Complete removal and displacement of the soil causes destruction of soil structure, some inevitable loss of topsoil and the possible deposition of toxic or non-productive material in the root zone of the plants to be reestablished. Vegetation reestablishment will be difficult in some areas and may be impossible in others.

Archaeological and Paleontological Values

An archaeological and paleontological survey has been conducted by the Montana University Statewide Archaeological Survey on the lands to be mined. No archaeological sites or paleontological remains of any consequence warranting excavation or preservation were found.

It is recognized that the moving of overburden in the mining procedure and the establishment of permanent structures will destroy all minor and unimportant sites heretofore identified by the field examinations. Likewise, any unidentified sites, unless detected, will be destroyed.

Besides direct impact of mining, there will be some indirect impacts associated with the population increase expected to be generated by expansion and operation of the mine. Increased population will permanently remove and disturb additional acreage which could possibly contain archaeological values.

Recreational use associated with this population could impact unknown archaeological sites throughout the study area. Arrowhead hunters, rock collectors, pot hunters, and off-road vehicle users will all disturb additional surface acreage, destroying evidence which could provide information on archaeological sites.

Historical Values

James D. Keyser of the University of Montana Statewide Archaeological Survey reported that the DeMaegt cabin was the only structure of historical interest on the Amax property (Appendix G). There should be no adverse impacts on this structure due to the mining operation.

Aesthetics

The impact on aesthetics will be gradual over time. Intrusions have been added to the landscape prior to and at the beginning of mining. Other changes will take place over the period of 25 years covered by the mining plan.

The mining operation will impact the existing landscape character by changing the form, line, color, and texture. Disturbance of vegetation, removal of overburden, and creation of new landforms will cause a change in the appearance of the landscape.

A color contrast will be evident where the mixed soil from the mine joins the undisturbed natural soils and where the new vegetative cover on the reclaimed land meets the undisturbed sagebrush and grass.

Vegetation and landform will change from a coarser to a smoother texture due to reshaping to a smooth landform and the planting of a softer-textured vegetation. Eroded, rough, broken land will be graded to more gentle slopes. This will all result in less variety and natural configuration in the landscape, thereby reducing the quality of the landscape character.

Intrusions such as roads, powerlines, railroads, pipelines, base area building, and other structures will add discordant character to the natural landscape.

Other impacts on landscape character will be the general lowering of the profile in the mined area and the resultant highwall left at the edge of the mining operation. Where the mining operation meets other mining leases or property lines, a discordant landform could result.

Wildlife and Fish

Some 2,890 acres are involved in the total Amax South operation. Most of this will be disturbed at the rate of 126 acres per year. The extent of the effects on wildlife and fish will vary due to species, adaptability, mobility, etc.

The deer (about 50 animals) inhabiting the area along Caballo Creek will probably be lost unless they will move and can find other suitable and unoccupied habitat. As they are creatures of strong habit but considerable adaptability, it is difficult to make a definite prediction.

Antelope, on the other hand, occur in far greater numbers--about 266 on the affected area. It is tempting to say that, since only 126 acres per year will be disturbed, these animals will be able to assimilate into adjacent habitat. However, the adjacent habitat is apparently inferior. And the fact remains that some 2,890 acres of habitat will be lost or at least drastically altered. There is no definite assurance of successful rehabilitation, and according to the mining plan, the character of the reseeded vegetation will probably be different in any event.

Riparian habitat will essentially be lost. What water remains could become polluted. Some of the animals and fish associated with the disturbed portion of Caballo Creek will be destroyed. Watering sources will be disrupted, destroyed, or possibly polluted.

The possibility exists that the level of Caballo Reservoir may be lowered by mining, thus producing off-site effects.

Sage grouse habitat, including a strutting ground, will be lost or drastically changed in character.

Burrowing animals will be lost, including a great many which ordinarily serve as prey for raptors and carnivore populations.

A remote possibility exists that toxic elements, oil, grease, and sediments could find their way all the way to Keyhole Reservoir via the Belle Fourche River, adversely affecting this fishery.

The effect of the proposed action on endangered species should be insignificant.

Recreation

The proposed mining operation will disrupt present patterns of recreation activities on the lease and adjacent areas.

The mining operation and base plant site will eliminate approximately 400 acres of hunting area on an annual basis throughout the life of the mining. This will affect approximately 8 visitor days of use per year.

Improved access will be available for recreation activities. Hunting can be expected to increase due to better access and increased human population. Elimination of vegetation and reduction of wildlife habitat and populations could affect hunting quality on and adjacent to the mine property.

Other activities can be expected to increase except for artifact hunting which will be slowly eliminated as the mining progresses. Sightseeing may increase because of the interest in the mining activity and the desire to capture it on film.

Agriculture

Livestock forage

An estimated 1,017 AUM's (animal unit months) of annual forage production will be disrupted during the 25-year period of mining. Much of the land will only receive fringe impacts, such as dust, for many years until actually mined. After the initial pit is mined so that refilling can begin, the plan calls for rehabilitation of approximately the same amount as is mined each year. Thus, the possibility exists for some reinstatement of the grazing capacity each year. The degree is entirely dependent on the success or failure of the rehabilitation program.

The relocation of the county road will destroy a total of 85 acres or 28 AUM's of annual forage production.

The useable facilities which will be destroyed are one livestock watering pond, one open shed with corrals, one ranch headquarters, and eleven miles of boundary and interior fences. Some of these would be salvageable to a certain extent.

Unprotected highwall areas in the mine will create falling type accident hazards for livestock.

Invader species of plants will become established on soil piles. They could include noxious weed species and species known to be toxic to grazing livestock, thereby resulting in a loss of those areas for grazing purposes.

Wildfires could be caused by the mining activities and the railroad, destroying vegetation on the land and adjacent areas.

Farming

No impacts on farming are expected, as no farming is practiced on the land at the present time.

Transportation Networks

The county highway will have to be temporarily relocated when mining reaches the road. After a period of 3 or 4 years, the road can be relocated in its present route across the reclaimed land.

The road connecting the county road with State Highway 59 also runs through the western part of the lease. This road will be relocated for a longer period of time since the mining under this road will last for several years. A total of 4½ miles of gravel road will be destroyed by mining.

Increased traffic created by populations increases and employment at the mine will impact existing roads. Since the workers will probably live in Gillette, the county roads west to State Highway 59 and Highway 59 north to Gillette will be affected the most. Congestion and road deterioration may result from this increased use.

Neither the short railroad spur route nor the electric transmission lines have significantly impacted or interrupted existing transportation facilities. Bishop Road is the only major thoroughfare crossed by the railroad.

Socio-Economic Conditions

The major socio-economic effects generated by expansion of this operation will be those associated with employment, population, employee income, and other revenues.

The Belle Ayr South Mine is expected to have a 25-year life, with extraction operations continuing until about the year 1997. Construction of additional mine equipment and facilities will require about 100 people for a period of about two years. Employment of permanent mine personnel will increase from about 72 in January of 1975 to an estimated maximum of 250 in 1977.

The following table shows, for selected year, estimates of the number of mine and construction personnel, other mine generated employment, total projected increases in population due to the mine employees and wages earned by the mine and construction workers.

	1975	1980	1985	1990
Mine Employment	120	250	250	250
Construction Employment	100	-	-	-
Other Employment	220	250	250	250
Total Population Increase	990	1,125	1,125	1,125
Wages from Mine Employment Only*	$1,800,000	$4,786,058	$6,108,358	$7,795,985

*Assuming an average salary of $15,000/year in 1975 and inflation adjustments of 5 percent per year.

At the projected maximum annual production level of 15 million tons, and an assessed value of $1.30 per ton, the operations will generate $585,000 per year from the coal excise tax.

The State of Wyoming will receive directly 37½ percent of the production royalties from the Federal leasehold to be spent on schools and public roads. The total projected direct revenue to the State and county would amount to $1,125,000 per year from the Belle Ayr South Mine, based on a projected maximum production of 15.0 million tons at a production royalty of 20 cents per ton. In addition, 52½ percent of the royalties are placed in the Reclamation Fund to be spent for water development projects in semi-arid regions of the United States. The remaining 10 percent goes to the Treasury of the United States.

Additional population will increase the demand for services, protection, water supplies, sewage disposal facilities, and housing. The problems associated with increased population densities such as crime, social problems, and unemployment may increase.

A detailed discussion of the cumulative socio-economic impacts of this and other projected operations in the Eastern Powder River Basin can be found on pages I-554 through I-611 of FES 74-55.

CHAPTER IV

MITIGATING MEASURES

General

The proposed mining operation would have to comply with all applicable regulations of county, State, and Federal agencies, including, but not limited to, the U.S. Geological Survey, the Bureau of Land Management, the U.S. Environmental Protection Agency, the Mining Enforcement and Safety Administration, and various agencies of the State of Wyoming concerned with air and water quality and with surface mining regulation and enforcement. The regulations of these agencies are variously designed to assure the realization of the full and best interests of the public, the maximum protection of our environment, and productive use of the land.

In addition to the above regulations, section 5 of the lease covers protection of the surface and provides for reclamation of the land. A bond is also required which covers compliance with all of the lease terms. The amount of the bond may be adjusted as necessary so that increases in estimated compliance costs are adequately covered.

A summary of some of the applicable laws and regulations along with a number of general stipulations for mitigating possible adverse effects of coal development in the Eastern Powder River Coal Basin can be found on pages I-612 through I-644 of Chapter VI, Volume II, FES 74-55.

Supervisory Responsibility of the Geological Survey

The Secretary of Interior has delegated to the U.S. Geological Survey certain responsibilities in the Public Lands lease management activities of the Department of the Interior. These responsibilities are designated in Secretarial Orders, Regulations, and the Departmental Manual.

On October 6, 1972, the Secretary of Interior issued Order Number 2948 to update the division of responsibilities between the U.S. Geological Survey and the Bureau of Land Management (BLM) in the Department's Mineral Management Program. Under this order, the BLM exercises the Secretary's discretionary authority to determine whether or not leases and permits are to issued. The BLM, in cooperation with the Geological Survey, formulates requirements to be incorporated in leases and permits for the protection of the surface and non-mineral resources. BLM reviews exploration and mining plans submitted to the Geological Survey for approval, for adequacy of surface use, environmental protection, and reclamation aspects.

BLM is responsible for compliance examinations of environmental protection requirements outside the mining plan area and for reporting such infractions to the Geological Survey for discussion with, or issuance of, orders to the operator. With respect to public land, BLM approves access roads and requests for surface use outside the mining plan area, but must obtain the recommendation of the Geological Survey before taking final action.

The Geological Survey exercises the Secretary's delegated authority regarding operations conducted within the mining plan area and determines actions to be taken by operators for development, conservation, and management of mineral resources under the jurisdiction of the Department.

In addition, the Geological Survey approves or disapproves exploration and mining plans after consultation with and the concurrence of BLM. The Geological Survey examines operations to ensure compliance with environmental protection and reclamation requirements and issues orders for compliance within the operating area.

Once the exploration or mining plan is approved, the Area Mining Supervisor must make on-site inspections at least three times a year to assure that the lease terms, the regulations, and approved exploration or mining plans are being complied with. The purpose of supervision is to assure the orderly and efficient development of minerals on Federal lands. A report is written following each inspection as to whether the operator is in compliance with the lease terms, operating regulations, and the approved plan. If not in compliance, the steps ordered and recommendations for compliance are enumerated. The report is placed on file for public examination at the office of the Mining Supervisor, except to the extent that it contains trade secrets, or financial, commerical, geological, or geophysical information. The District Manager of the BLM will also make compliance checks and report any infractions to the Area Mining Supervisor.

The inspections are made to determine how mining or exploration operations are being conducted and to see that surface disturbance is not excessive. Especially critical are the method and location of waste disposal and whether overburden is being properly and timely reshaped to prevent soil erosion and to blend in with the surrounding topography. The inspections also insure compliance with the regulations that reclamation be kept as concurrent with mining as feasible. The amount and type of revegetation are noted, as well as the success of the revegetation.

The Area Mining Supervisor of the U.S. Geological Survey discusses with the operator any violations observed and requires that they be corrected in a specified period of time. These violations are confirmed in writing to the company and to the Supervisor's superiors and made part of the public record on file at the office of the Mining Supervisor. If the violations are not corrected in the specified time, the Supervisor may suspend operations or request that BLM initiate action to cancel the lease or permit. The inspection also includes a check of production and sales records to assure that the Government is receiving the proper amount of royalty. The Area Mining Supervisor and the District Manager of the BLM are encouraged to make periodic inspections jointly.

The operator is required to report as soon as possible to the Geological Survey any environmentally degrading accident, and accident to personnel or visitors, or any failure of the approved plan to function as expected. Oversights in the plan will be corrected by modification as provided for by the operating regulations. In addition, the operator reports and pays quarterly the royalty on the amount of coal produced and annually pays the rental. These reports and records must be kept current by the operator and made available upon request by authorized representatives of the Geological Survey.

Current mine maps are required semi-annually, and a report on the acreage disturbed and reclaimed is required annually as is an audit of the operator's financial records by a Certified Public Accountant.

Air Quality

All activities affecting air quality must comply with State and Federal air quality laws and standards as set forth in FES 74-55, pages I-613 to I-616, and summarized in Appendix D of this statement.

The primary mitigating measures will be revegetation to control dust, and emission control devices. Dust from denuded areas and roads will be minimized by reclaiming spoil piles as soon as possible after mining, treating roads to reduce dust, irrigating areas to hold dust on the ground and hasten revegetation, and placing chemical or physical covers over exposed areas to prevent dust from lifting into the air.

Coal piles will be minimized by shipping coal as soon as possible and limiting storage on the site. This will reduce the chance of high winds blowing coal dust and reduce the opportunity for coal to burn on the site.

Emission control devices will be used to reduce gaseous and particulate matter from vehicles, processing plants, and heating plants.

State, Federal, and industrial fire prevention campaigns may reduce the number of fires. Open burning of all materials will be in accordance with suitable practices for fire prevention and control. The construction of firebreaks along roads and railroads and around mining activities will limit the extent of fires. Firefighting equipment will be required on the site.

The use of spark arrestors on equipment will cut down on accidental range fires. On turbo-charged equipment and locomotives which cannot use spark arrestors, using a high quality diesel fuel will minimize sparks.

Topography

The mining and reclamation plan filed with the Federal Government, in conjunction with Federal regulations, State laws, and the coal lease terms, requires action to mitigate the adverse topographic effects of surface mining. Spoils will be graded to a rolling topography, with no slopes steeper than 11 degrees. Highwalls will be reduced to slopes no steeper than 30 percent to blend with the surrounding terrain and slopes and final pits will be filled with material from adjacent spoil banks and highwalls. The spoil banks, highwalls, and final cuts will then be covered with a layer of soil material spread to a depth of not less than 6 inches and revegetated as soon as practical. All exposed coalbeds will also be covered to a depth of at least three feet with incombustible material.

The restored landform will be determined by consultations among the lessee, the appropriate Federal land management agency, the Wyoming Department of Environmental Quality, the U.S. Geological Survey, and the surface owner. Consultations will be frequent enough so as not to impede the progress of the mining or reclamation. Prime consideration in grading and shaping will be the catching and holding of any waters falling on the area to improve the soil moisture conditions and ground water recharge, and catch and hold sediment in such a manner as to protect downstream areas.

Surface water may accumulate toxic elements or deleterious salts which could become concentrated and deposited along the shore due to evaporation of closed water bodies. Therefore, during the shaping of the spoil into the final landform, no closed interior ponds will be permitted.

An example of one of the possible pasture and grazing landforms, following reclamation, is shown in Figure 19. The other major possible configuration proposed by the company would yield two lakes within the mine area along the restored course of Caballo Creek. An artist's conception of this final landform is depicted in Figure 20. Any lake created must contain water which will be suitable, on a permanent basis, for its intended use and must be of such a quality that its discharge will not lower the existing quality of Caballo Creek.

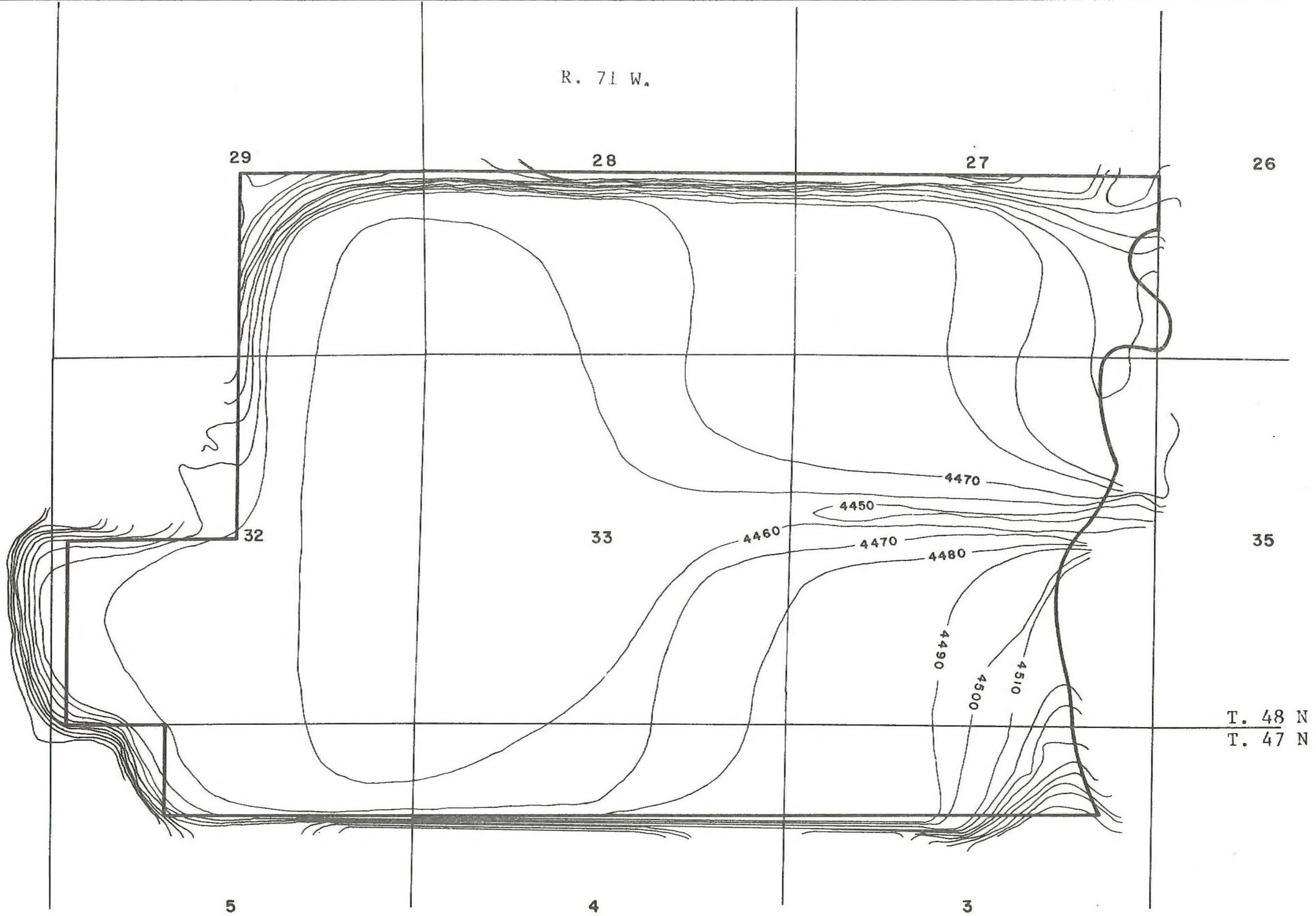
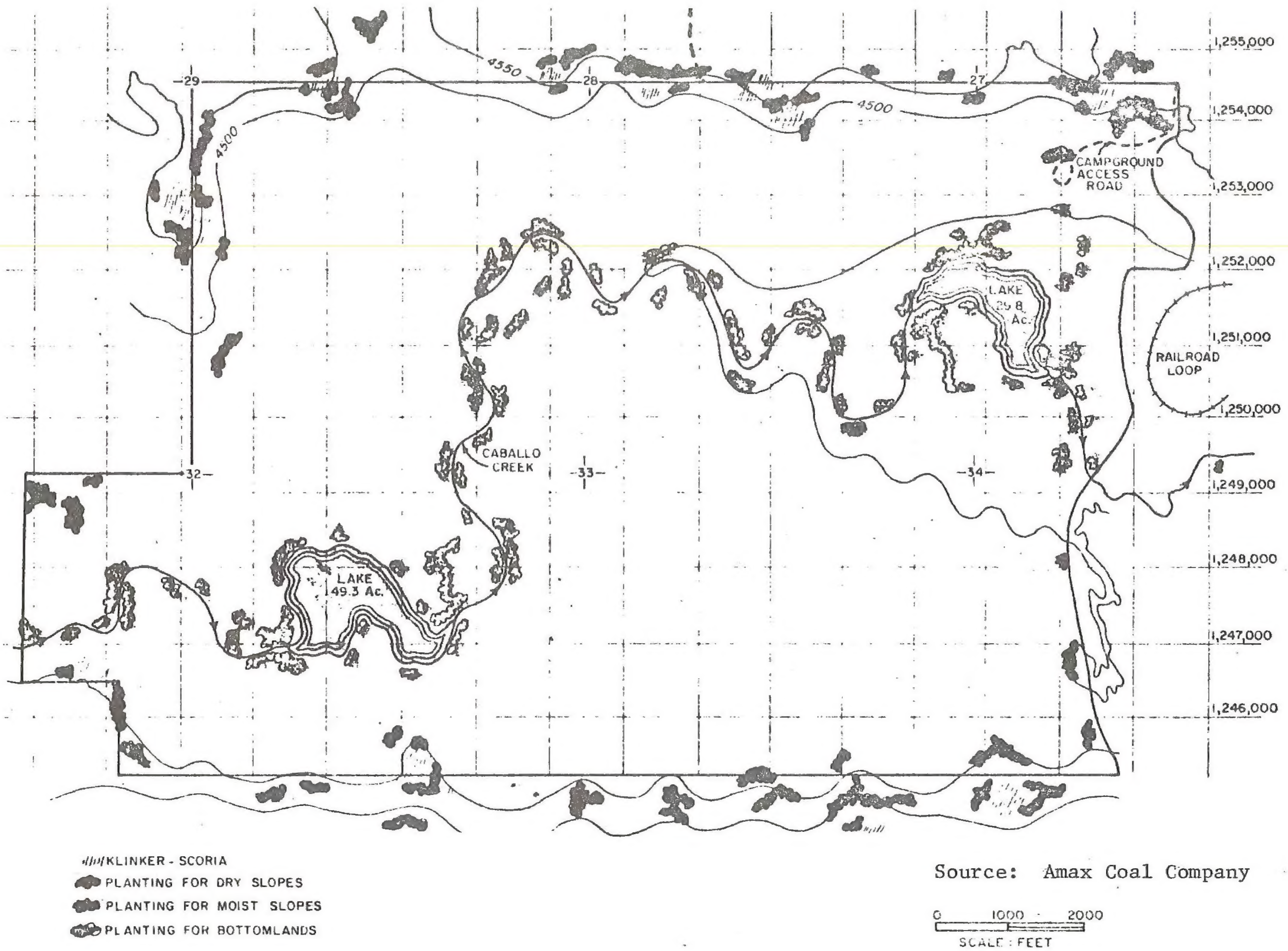

R. 71 W.
29
28
27
26
32
33
35
4470
4450
4460
4470
4480
4490
4500
4510
T. 48 N
T. 47 N
5
4
3

Figure 19

Topography after reclamation is completed - Pasture and Grazing Alternate

Belle Ayr South Mine


4550
4500
4500
4500
29
28
27
32
33
34
1,255,000
1,254,000
1,253,000
1,252,000
1,251,000
1,250,000
1,249,000
1,248,000
1,247,000
1,246,000
CAMPGROUND ACCESS ROAD
LAKE 29.8 Ac.
RAILROAD LOOP
CABALLO CREEK
LAKE 49.3 Ac.
KLINKER - SCORIA
PLANTING FOR DRY SLOPES
PLANTING FOR MOIST SLOPES
PLANTING FOR BOTTOMLANDS
0
1000
2000
SCALE: FEET

Source: Amax Coal Company

FIGURE 20

Artist's Conception of Final Reclamation Showing Two Lakes Along Restored Caballo Creek

Soils

Impacts to soils can be minimized by including and enforcing protective stipulations in the Federal authorizations.

Application of certain land treatment practices will minimize: loss of topsoil and productivity; disruption of physical, chemical and biological properties; soil loss by wind and water erosion; and compaction. To minimize the loss of available topsoil, it will be removed and stockpiled for later replacement on disturbed areas. Mechanized equipment, such as scrapers, will be used to minimize soil mixing.

Ripping and cultivating the soil surface prior to seeding will minimize soil compaction effects. Restriction of unnecessary off-road vehicle use by equipment operators and employees will also minimize soil compaction in those areas.

Soil erosion will be minimized by mulching, revegetation and development of water erosion structures including water bars, terraces, contour furrows, grassed waterways and interceptor ditches to divert running water away from unprotected disturbed areas. Wind erosion will be minimized by roughing up smooth exposed soil surfaces with a disc, harrow, or similar equipment immediately after clearing is completed. Seeding or revegetation will be accomplished within one year after clearing of vegetation.

Detailed soil inventories will be provided by Amax Coal Company. The inventories will be conducted in accordance with standards designated by the Bureau of Land Management to map and identify each soil series situated within the lease area. Soil samples will be collected to a depth of 60 inches or bedrock for physical and chemical analysis. Chemical tests will include organic matter, pH, exchangeable sodium percentage, boron, sodium, chloride, calcium, selenium, nitrogen, phosphorous, potash, sulphur, base saturation, cation exchange capacity, and conductivity. Physical tests will include standard soil mechanical analysis and engineering properties. Soil mineralogy and moisutre relationships will be determined. Additional soils information will be collected after topsoil has been replaced and before seeding to determine profile, chemical, mechanical, and mineralogy changes in the upper 60 inches.

Samples of the overburden formations from the surface down through the deepest coalbed to be mined into the strata immediately underlying this bed will be collected for chemical tests to determine presence or absence of toxic or undesirable elements or material. Results from current or past research studies on revegetation and reclamation of disturbed areas will be applied in treating the disturbed onsite and offsite areas.

Construction designs will include mechanical treatment practices such as contour furrows, terraces, and mulching to retain moisture onsite to benefit revegetation and reduce soil loss. Design will include control measures such as diversion ditches, waterways, and water spreaders to reduce sediment yield and runoff from compacted areas or concentration of runoff waters. Studies and investigations are necessary to identify and prevent productive downstream soil units, which are presently sustaining desirable vegetative communities, from being deprived of soil moisture.

Solid and liquid wastes will be disposed of in accordance with State and Federal regulations. Disposal sites will be located so as to minimize any detrimental effects upon the environment. Service haul roads; material sites for sand, gravel ballast; campsites; and equipment storage areas will be cleaned up, scarified, rehabilitated to near natural condition and revegetated. The edges or vertical sides of all excavated material sites and borrow areas will be sloped to a maximum 3:1 slope to minimize sloughing and aid revegetation. Contingency plans must include measures to clean up accidental spillage of detrimental or toxic materials such as gasoline, oils, chemicals, and restore damaged soil to a near natural condition.

Service and haul roads that are susceptible to producing dust and sediment will be surfaced or treated with a binder of water. Chemical binders, surfacing materials, and use of herbicides must meet State and Federal approval.

Water Resources

Availability of water from deeper aquifers

Water well supplies affected by lowered water levels in the radius influenced by dewatering for mining could be replaced by deeper wells. The chemical quality of water in the deeper Fort Union Formation is similar to or better than that in the overlying Wasatch Formation, which constitutes the overburden.

Monitoring programs

Monitoring programs are being established by the company in the area. A number of the monitoring programs are being planned in consultation with the Water Resources Division of the U.S. Geological Survey and with the Water Resources Research Institute of the University of Wyoming. The programs consist of establishing observation wells to determine water level fluctuations in coal and overlying overburden. Water samples are being collected to determine quality of the water and for detecting changes in water quality after mining begins. As mining progresses, observation wells will be established in backfill areas to monitor for leaching and movement of toxic materials.

Water quality

The enforcement of all applicable Federal and State laws and regulations concerning water quality standards will reduce the cumulative effects of regional development on water quality. These include:

1. Federal Water Pollution Control Act, as amended in 1972, and as it may be hereafter amended;

2. Wyoming Environmental Quality Act of 1973; and

3. Water Quality Standards for Wyoming, Wyoming Department of Health and Social Services, State of Wyoming, June 28, 1973.

Water supplies

Wyoming water law requires water-right filings for water impoundments and for the general utilization of water from ground or surface water sources. If the mining activity interferes with existing ground or surface water rights, it may be required that water be provided to satisfy these existing rights.

Provisions under Wyoming water law make it possible to change the location of a well, a reservoir, or irrigated lands that are affected by activities such as mining without affecting these water rights. This would prevent the loss of these facilities and of irrigated lands and, in many instances, would reduce the impact of the mining activity.

The appropriation of and the supervision and distribution of ground and surface water is under the control of the Wyoming State Engineer and the Board of Control.

Vegetation

Initial revegetation measures will be started within one year following reshaping of the land and topsoil replacement. Revegetation measures will be continued beyond the initial attempt until a satisfactory stand of vegetation is established that can be maintained without irrigation.

Plans to revegetate the disturbed land will be approved by the Area Mining Supervisor after consulting with the Bureau of Land Management. Stipulations will be developed and included in the mining plan to meet the revegetation objectives. Additional stipulations that will be considered for inclusion in the approved mining plan are as follows:

Damage to native vegetation will be minimized by keeping the acreage of disturbed areas (other than strip-mined areas) to an absolute minimum.

Seed will be drilled into the soil on a contour pattern. The depth of drilling will be determined by the seed mixture and could average 1/2 to 3/4 inches.

Deposition of dust, coal dust, and harmful chemicals on vegetation will be reduced by watering haul roads and installing dust suppression controls on mining, transporting, processing, and loading equipment.

Proper precautions will be taken at all times to avoid fires.

Continuing revegetation research projects are in progress at the mine site. The results of this research, along with the completion of a more detailed vegetation survey and analysis of that data and the preliminary data now available, will enable specific stipulations to be developed to protect the important plant communities on or adjacent to the property.

Archaeological and Paleontological Values

Legislative authorities and obligations which guide issuance of Federal license to develop the Powder River coal resources are: 1) the statute commonly referred to as Antiquities Act of 1906 (34 Stat. 255, 16 U.S.C. Sec. 431-433); 2) Wyoming statutes relating to archaeological and paleontological sites (Sec. 36-11 to 56-13 and 18-330.7 W.S. 1957); 3) an act for salvage at reservoir sites as amended (74 Stat. 220; 88 Stat. 174, 16 U.S.C. Sec. 469-469c); 4) an act for historic preservation (89 Stat. 915, 16 U.S.C. Sec. 470-470m); 5) National Environmental Policy Act of 1969 (83 Stat. 852, 42 U.S.C. Sec. 4321 et seq.); and 6) Executive Order 11593, May 13, 1971 (36 FR 8921).

A description of the provisions of these various legislative authorities is contained in Part I, Volume 2, pages I-637 through I-639, of FES 74-55.

Field examinations of the lands in the South Belle Ayr leasehold were made both in 1971 and 1974 by personnel of the Montana University Statewide Archaeological Survey. Permission to conduct the surveys was obtained from the Wyoming State Archaeologist, who has reviewed the findings and concurred in the recommendations. (See Appendix G).

No mining plans, permits, or rights-of-way will be approved until the company has coordinated its archaeological surveys with the Wyoming State Historic Preservation Officer and complied with all of his recommendations. In addition, all approvals will require that notification be given to the Area Mining Supervisor of any archaeological and paleontological sites discovered during mining and to the appropriate officer of the Bureau of Land Management of sites discovered during right-of-way construction.

The company has been advised to be alert for any sites which were not detected during field examinations. If presently unlocated sites are found during mining, Amax Coal Company will be responsible for protecting them from damage or destruction until they can be examined by a qualified archaeologist and salvaged if they are considered by him to be sufficiently valuable.

Historical Values

The historical value survey has been conducted on the lease area. The only site found was a homestead constructed of clinker, located just southeast of the Belle Ayr South Mine. The Amax Company is presently restoring the homestead site as an added attraction for visitors to the mine. Additional information on the site can be found in Appendix G. According to the State Historian, the possibility exists that new information could be found that would place value on a previously unimportant site. Any approval given will require notification of the Area Mining Supervisor if any historical site is discovered during mining, and the company will be responsible for protecting the site from damage or destruction until it can be examined.

Aesthetics

Reclamation landforms must be reshaped and blended into the undisturbed land to reduce or eliminate the contrast in form, line, and texture. In other words, smooth terrain should join smooth terrain, and rough terrain should join rough terrain so that a gradual blending with the adjacent natural areas takes place.

The color, line, and texture contrast between existing and introduced vegetation types will be reduced or eliminated by using a mixture of native species, including sagebrush, on the rehabilitated areas. On pipeline rights-of-way where long, straight segments usually occur, the line dominance will be reduced by planting sagebrush and grass in irregular patterns on the right-of-way.

Structures will be kept as low as possible on the skyline. They can be placed in natural depressions and telephone and low-voltage powerlines can be buried.

Wildlife and Fish

Mitigation of adverse effects on wildlife and fish over the long term will depend upon how the land is restored, on what type of vegetation is seeded, and on how well it is established. A variety of species of shrubs, grasses, and broad-leaved plants will be used including sagebrush, a vital component of winter antelope, deer, and sage grouse habitat. Monocultures, especially pure grass, will be avoided. Leveling for irrigation and crop purposes should be avoided but may be required by the surface owner.

The proposal for two lakes along Caballo Creek, one of 29.8 acres and the other for 49.3 acres, may provide fish habitat and could replace some of the waterfowl habitat lost during mining. There is no guarantee, however, that water quality after mining would permit a fishery or that public access will be permitted. It will be required that permanent impoundments contain water which is suitable, on a permanent basis, for the intended use and that the discharge from the impoundment not lower the water quality of the receiving stream.

Any fencing done will be kept to a minimum and designed to allow free movement by antelope. Type and locations should be coordinated with the Wyoming Game and Fish Commission.

Recreation

Trees and shrubs which are desirable as shelter for wildlife will be planted on the mine area to aid in reclaiming parts of the land as wildlife habitat. In doing this, sightseeing and hunting opportunities should be improved.

If, under existing laws and water rights, the creation of water-oriented recreational land is possible, parts of the Belle Ayr South Mine area could be reclaimed to provide fishing lakes, campgrounds, and other desirable recreation facilities.

If any lakes are constructed for this purpose, the company will be required to leave slopes on the shoreline which will facilitate access for fishermen and will provide for waterfowl nesting and fish-spawning grounds.

The restoration of the DeMaegt clinker homestead by the Amax Coal Company should provide historical interest for sightseers.

Agriculture

Measures that may be taken to minimize the effects of mining on livestock grazing will be initiated at the appropriate stages of the mining procedure.

Temporary fences will be erected around the areas actively involved in mining so that the remainder of the area will be available for livestock use or other uses as designated by the surface owner, and the hazards from highwalls and mining equipment to the livestock would be minimized.

Topsoil will be stockpiled in sufficient amounts to provide for placement on spoil piles at a depth not less than six inches. This will enhance plant growth for livestock forage during reclamation.

Where operations could result in acid or saline drainage or sedimentation of adjoining land or streams, provisions will be made for impoundments. Impoundments will be constructed and placed so as not to affect adjacent landowners or contribute to water pollution. When feasible, erosion control and flood control structures will be built prior to starting excavations.

All operations will be conducted to avoid wildfire and spontaneous combustion in order to protect adjacent rangeland.

Stock-water wells to be breached will be plugged with concrete to a point not less than 20 feet below the final proposed mine floor. After spoil rehabilitation is complete, new wells will be drilled to replace those destroyed.

Transportation Networks

To mitigate impacts on traffic flow due to highway relocation the company will have to allow traffic to travel undisturbed over the existing roads until the realignment is completed. As required by the Mining Supervisor, Amax Coal Company will have to provide alternate routes of access to any ranching or other local operations that would be completely isolated due to obliteration of roads within the mining lease.

CHAPTER V

PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

Air Quality

Adverse impacts on air quality, resulting from the continued mining at the Belle Ayr South Mine cannot be avoided. Some coal and soil dust, created by mining 331 million tons of coal, and disturbing a total of 3,018 acres over the 25-year period, will occur. About 126 surface acres will be disturbed in any one year, and 500 acres may be bare at any one time.

Even with proper emission controls, emissions from vehicles, equipment, and accidental fires will occur causing a reduction in air quality on the lease site and downwind. As there are no effective emission controls for diesel locomotives, emissions from train operations cannot be avoided. These emissions are expected to reach a peak by 1977 and remain fairly constant thereafter.

Some baseline data on the air quality with regard to particulates are given in Appendix D. No estimate can be given as to the increased quantity of particulates that will be produced by the operation when production reaches its maximum level.

Topography

A reduction in altitude caused by mining thick beds of coal with thin overburden cannot be avoided. The decrease in altitude over the lease area will range from a maximum of 67 feet to a minimum of 25 feet. The average drop will be about 48 feet.

Destruction of natural features of the landscape is unavoidable. Even though the general topography of the area can be restored at a lower level, cliffs and abrupt breaks, presently a part of the topographic scene, cannot be restored. The exact slope and angle of the present topography is unrestorable.

Change in the drainage channel of Caballo Creek cannot be avoided.

Soils

Disturbance of topsoil on a total of 3,018 acres (2,890 mined, 128 mine facilities) cannot be avoided. The disturbance of topsoil will lower to some degree the natural soil productivity of the area by mixing the soil profile, by compaction and causing accelerated soil erosion. Topsoil on 147 acres has already been disturbed in connection with the existing operation.

On the area to be mined, the destruction of all soil horizons, and soil characteristics, which have developed over long periods of geologic time, cannot be avoided. The existing soil biota will be reduced or terminated. Once mining is completed and the area reclaimed, soil development processes will start again on the mixed pre-existing soil materials. As an end result, new soils will be formed with some characteristics different from those existing prior to mining.

Reduction of soil productivity, permeability, and infiltration rates are unavoidable. Increase in erosion and sedimentation rates will occur, but amount of soil loss through time cannot be determined.

Mineral Resources

The only minerals to be affected by the mining will be the coal and clinker.

The total amount of coal to be mined at the Belle Ayr South Mine is small compared to the total coal reserves of the Gillette area. The mining plan covers an area where the coal has relatively little overburden, and the coal can be mined inexpensively. Therefore, this deposit has more value than the coal with much thicker overburden. The main adverse effect of mining the coal is that the most desirable reserves will be depleted, leaving less desirable reserves to be mined in the future.

The mining will have very little adverse effect on the clinker deposits. Only a small part of the available clinker will be used in the mining operations.

Water Resources

The amount of water consumed in mine operations will be unavoidably lost for other uses. This amounts to around 100,000 gallons per day.

The adverse impact resulting from the interruption of aquifers during mining cannot be avoided. Lowering of water levels of wells, and drying up of springs and seeps will occur in an area around the mine when aquifers are disrupted. The location and extent of this area of influence around the mined area will vary depending on various aquifer properties.

Development of lakes, ponds, and pits of water at the completion of mining may result where thick coal beds are mined which have thin overburden levels. This will be adverse to the extent that it depletes streamflows and adds to evaporation loss of water which then is not available for other uses (agriculture, stream fishing habitat).

A reduction in water quality from increased erosion and sedimentation will occur to some degree. The amount cannot be estimated.

Vegetation

Vegetation will be disturbed or destroyed on 3,018 acres.

About 275 acres of vegetation (primarily sagebrush) has already been disturbed by the mine and ancillary facilities. During the life of the mine an estimated 2,743 additional acres will be disturbed or destroyed. This acreage consists of 1,570 acres of sagebrush, 728 acres of grassland and 445 acres of cultivated land seeded to crested wheatgrass. The sagebrush acreage will be impacted first until about 1983 when mining will shift to the grassland surface on the southern part of the lease.

Reclamation of areas disturbed by the road relocation will occur shortly after disturbance. However, success of revegetating the severely disturbed mined area is unknown at this time.

All plant succession is unavoidably destroyed at the time of disturbance. Fifty years or more of plant succession will be required for these areas to return to their present state because the existing soil structure and microclimate will have been changed.

Even on areas that are successfully reclaimed, a significant loss in productivity has been projected.

Archaeological and Paleontological Values

Some archaeological sites and material could occur below land surface in the thin, unconsolidated soil material overlying bedrock. Discrete artifacts and small, incoherent sites in the subsurface might go undiscovered and be displaced and reburied during mining and construction. Similarly, some material can be expected to be scattered, lost, and buried during archaeological examination and inventory of sites. Permanent denial of information or the permanent loss of a single and only diagnostic site is most unlikely.

Aesthetics

The appearance of a mine in this remote area is a disagreeable sight to some people. The stripping shovels or draglines along with the coal storage silos can be seen on the horizon for miles. The trucks and other mining equipment create offensive activity on a peaceful landscape. On the other hand, other people consider the mine and its attendant activity an interesting addition to the landscape.

The added structures, roads, rail lines, and powerlines are discordant intrusions added to the natural landscape. The natural landscape (shape, texture, color) has been and will continue to be changed unavoidably. Even after reclamation, the disturbed areas will be discernible for many years. If the reclamation option to create cultivated fields along the stream is accepted, the land would be less scenic after reclamation.

Wildlife and Fish

Though acreage mined will be on a gradual basis, the short-term result will probably be loss of most burrowing animals, loss of the amphibians, reptiles, and other animals associated with Caballo Creek, displacement and loss of habitat for a considerable number of mule deer (50) and antelope (266), and loss of prey species for raptors and other predators.

Nesting habitat will be lost for a variety of songbirds and raptors. Some of these birds will find niches available in adjacent habitat; many will be unavoidably lost.

Disturbance caused by mining activity may cause the cessation of nesting activity in the golden eagle nest at the west edge of the property.

Recreation

Loss of an estimated 8 visitor days of use per year and 400 acres of hunting area on an annual basis cannot be avoided.

Reduction of wildlife habitat, population, and quality will lessen hunter opportunities. Increased population will intensify recreational use, which could cause adverse reduction of recreation quality and deterioration of facilities.

Agriculture

It is impossible to accurately quantify the long term loss of livestock forage due to a lack of research on the subject on sites sufficiently similar to the land in question. A figure of 50 percent has been used in FES 74-55 for purposes of estimation. If this figure is used, it is estimated that 508 AUM's will be unavoidably lost due to the mining operation. An additional 28 AUM's will be lost for all practical purposes due to the county road relocation.

Transportation Networks

Increased traffic on all existing facilities cannot be avoided. The increase began in 1972 and is expected to level off in 1977 when the peak production level is reached. Road maintenance costs and frequency can be expected to increase, and these costs cannot be avoided.

Temporary inconvenience and poor travel conditions caused during maintenance of the facilities are unavoidable. It is impossible to predict the possible increase in train car accidents. With the number of trains required per day, the increased probability of these accidents occuring cannot be avoided.

Socio-Economic Conditions

Unavoidable adverse socio-economic impacts due only to this operation would be difficult to quantify. On a regional bases, the large influx of people necessary to service and operate the coal mines will create an unavoidable increased demand for services, housing, education, law enforcement, and fire protection, water supplies and sewage disposal systems. The rapid increases in population will accelerate the problems associated with increased population densities such as crime, social problems, and unemployment. A complete discussion and analysis of the total cumulative unavoidable impact of all projected operations in the area can be found on pages I-664 to I-668, Chapter VII of FES 74-55.

CHAPTER VI

THE RELATIONSHIP BETWEEN LOCAL SHORT TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG TERM PRODUCTIVITY

Mining will result in the introduction of additional roads and powerlines into an area already changed to some degree from its natural state by the existing mining activities.

The lease area will be committed to coal production for a period of about 25 years based on anticipated production levels.

As the coal is mined, the overlying soil and rocks will be removed and the affected acreage will be lost to grazing and rangeland recreation for a period of five or six years.

Impacts arising from the short term use of the environment will be minimized to the greatest extent practicable consistent with modern mining and reclamation practices. Grading of spoils will reduce ridges to a rolling topography aesthetically consistent with surrounding undisturbed areas. Replacement of soil material and establishment of vegetative cover will return mined land to grazing as soon as possible following extraction of the coal.

Mining will temporarily disrupt the flow of surface water. Ground water levels may be lowered locally because of the removal of parts of aquifers in unconsolidated material, sandstone, and coalbeds. Rainwater and water flowing into the mined area will probably be retained by infiltration into the spoils, creating perched water tables.

The preceding indicates that short-term use of parts of the leasehold for mining will be accompanied and followed by a period of reclamation and revegetation. Although the land's appearance will be permanently changed, its attractiveness should not be adversely affected. Other potential long term land uses may be impaired by introduction of heavy industry, housing developments, and development of other resources. In addition, coal used for power generation will not be available for other uses or for future use.

At maximum production, 126 acres will be disturbed each year with an equal number of acres undergoing grading and planting. At any one time the total area disturbed will be about 400 acres. Since final reclamation of a particular area is estimated to lag about five years behind mining, wildlife and livestock will be displaced for at least that period of time.

In summary, the land will be used for mining coal rather than for grazing and wildlife habitat for a period of five to ten years at which time the land should be restored to its former or other designated uses.

Disturbed land, presence of heavy equipment, other mine-related facilities, and associated noise, dust, and solid waste will be only of short duration. After mining, reclamation, and revegetation are completed, the principal long term changes will be local modification of the topography and surface drainage systems, a possible loss or reduction of productive capacity.

Wildlife habitat for those animals which depend on a sagebrush type (antelope-sage grouse) will be destroyed for a period of 20 years. This loss could be reduced by planting wildlife feed on the reclaimed land.

CHAPTER VII

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The major commitment of resources is the mining and consumption of 331 million tons of coal over the 25-year life of the mine. This loss represents about 2.7 percent of the economically strippable reserves of the Eastern Powder River Coal Basin.

Use of an indeterminable amount of sand and gravel and clinker for aggregate in the construction of the mine facilities, railroad loop, and access road will occur. Clinker, sand, and gravel deposits mined with the overburden and moved with other spoil will be irretrievably lost.

The only ground water aquifers that will be irreversibly commited are those aquifers that will be physically removed during mining. Adjacent parts of these aquifers will be affected during mining operations but water levels are expected to return to normal after mine dewatering stops. The chemical quality of water in the aquifers will not be changed.

Extraction of coal and reclamation of disturbed areas will require the use of electrical power, lubricants, liquid fuels, including diesel fuel and gasoline, ammonium nitrate explosives, and structural materials for construction and repair of surface buildings. Chemicals and materials used in mining and reclamation would also be lost for other uses.

Large amounts of diesel fuel will be used in transporting the coal via rail line. By 1985 the consumption of fuel just within the study area covered by FES 74-55 will amount to 7.2 million gallons per year. This fuel will be consumed and unavailable for future use.

Loss of life will occur both in the mining operations and association with increased vehicular and train traffic. Based on fatal accident rates experienced in the strip mining industry during 1972, one employee will suffer a fatal accident for every 14.3 million tons of coal produced. Disabling injuries will occur at the rate of 9.24 per million man-hours worked. Therefore, during the life of the mine an estimated 24 people will lose their lives. This will be an irretrievable commitment of human resources.

Any destruction of potential archaeological or paleontological sites will be an irreversible and irretrievable commitment of resources.

It is doubtful that total reestablishment of the complex native plant community is possible on disturbed areas of the mined area. Strip mining and associated activities will eliminate a portion of this life support community which is the major irreversible impact to wildlife in the area.

Wildlife resources that may be irretrievably lost include individual animals and habitats that are destroyed. Animals and plants that would have reproduced in the affected habitats during the life of the mining operation may also be irretrievably lost. Most wildlife losses may be reversible if the species and habitat are not impacted to the point that their ability to reproduce is seriously impaired.

The annual forage production which the area could have produced will be lost during the time that mining takes place. Production could be lost on 300 to 500 acres annually. This increment of production lost is an irretrievable commitment of the livestock forage.

Full productive capacity of the land may not be possible on areas severely disrupted by strip mining. Any reduction in productive capacity of the revegetated land over the previous capacity has to be considered an irretrievable commitment of resources.

CHAPTER VIII

ALTERNATIVES TO THE PROPOSED ACTION

Reject Mining Plan

The following discussion of alternatives was taken in part from FES 74-55. It should be noted that additional alternatives were considered in FES 74-55 and that they have been incorporated by reference into this statement. Some of the other alternatives considered included: Alternative Methods of Transportation, Alternative Sources of Energy and a Reduction in Energy Consumption.

Rejection of Belle Ayr South mining plan would result in no environmental impact on the leased lands not already mined and they would continue in their present condition or be modified by the surface owner to meet other uses as may be determined. Amax Coal Company could submit a new mining plan, challenge the rejection, or abandon -- at least temporarily -- development of the lease. Should the mining plan be rejected, the development of alternate sources of energy or a reduction of energy consumption could be required.

Amax Coal Company may also continue mining operations on their 690 acres of privately owned coal adjacent to their existing south pit with the same primary and secondary impacts as those evolving from the mining of both Federal and private coal. This private coal could sustain production at proposed levels through the year 1980. This would result in a mine on privately owned coal lands leaving the

Federal coal untouched and would (1) increase the overall extraction costs thereby resulting in possible higher costs for consumers of the coal; (2) result in increased mining problems and costs if, following reclamation, the Federally owned coal were later extracted; and (3) result in a loss to the State and county of a long-term tax base and a loss of the State's share of Federal royalty revenue distributed in accordance with the Mineral Leasing Act.

In addition, reclamation and enforcement requirements under State laws could be less stringent than those required by the Federal Government thereby affecting the restoration of mined areas.

In the event Amax chose not to mine on privately owned land as a consequence of rejection of a mining plan on the Federal leasehold, the coal for the power plants would have to be obtained from another source. In addition, most of the impacts discussed previously in Chapters III and V of this statement would not occur.

Approve the Mining Plan After Modification

Some of the impacts identified and discussed in Chapter V could be avoided if the mining plan were modified to require the use of one or more of the operational alternatives discussed below. In addition, special stipulations could be added to the plan to mitigate some of the secondary effects of the mining. Such conditions must be reasonable, and if unacceptable to the lessee, could result in the lessee not developing the area with the resultant impacts as discussed in FES 74-55 on pages I-669 through I-671 under the heading "No New Development of Coal."

Different rate of production

Amax Coal Company is scheduled to supply four million tons of coal to power plants in Colorado, Iowa, and the Ohio River Valley during 1974. Existing contracts will require a production level increase to 15 million tons per year by 1977.

Any change in production rate, either upward or downward, would alter the rate or intensity of the environmental impacts discussed previously in this statement. If a reduction in proposed production rate were required, it would create a shortage of fuel at the power plants in the areas of consumption, resulting in decreased power production when consumption is increasing unless substitute sources of supply were obtained. A reduction would also prolong mining activity on the leasehold, prolong the time until restoration is completed, lessen employment at the mine, lessen the acreage disturbed at any one time, and lessen annual tax and royalty returns to the State and county from Amax's Federal lease.

If the company were required to increase production above the level proposed, it would cause storage problems, with the possibility of fires in storage areas, unless additional new markets were found, increase the intensity and severity of the impacts described elsewhere in this statement, decrease the length of time for mining and reclamation, and increase annual tax and royalty returns from the Amax lease.

Different methods of mining

Underground mining

Substitution of this method of mining would result in less initial disturbance of the land surface, however, unsupported mine roofs between pillars would ultimately collapse because of the lack of structural strength in the thin overburden resulting in a partly subsided land surface degraded by numerous depressions and openings; greater costs because underground mining is more costly than surface mining; a decrease in mine safety as indicated by the fatal accident rates in 1972 of 0.42 per million tons mined underground compared to 0.07 per million tons for surface mining; and higher incidence of non-fatal accidents due to roof and coal falls, fires, explosions, and problems related to dust inhalation (black lung disease).

On Amax's Federal leasehold the coal bed averages 70 feet in thickness. Assuming that a 10-foot section could be mined safely by underground methods and that 50 percent of coal in the mined area was left in place to provide support and lessen the probability of surface subsidence, coal extracted would represent about 7 percent of the available coal in place. This rate compares to a present recovery of 90 to 95 percent of the available coal in place at the Belle Ayr South Mine.

In-situ production

Techniques for the economical burning of coal in-situ and capture of the released volatile gases are still in experimental stages. Present knowledge indicates that energy recovery levels of in-situ production are low and amount of surface subsidence in areas of thin overburden is highly unpredictable. Impacts associated with in-situ production would include the possibility of destruction of a coal bed aquifer, pollution of ground water, and air pollution from escaping gases.

For in-situ production to be a viable production alternative, methods for increased recovery of volatile gases must be developed. Such increases may then allow in-situ production to compare favorably with the high recovery of coal by surface mining methods.

Different utilization

Onsite power generation

Transportation and fuel costs for onsite electric power generation would be minimal, and there would be less chance for coal spilling than during transportation to offsite power generation plants. However, a coal burning electrical power generation plant would have to be constructed, transmission lines would have to be built, and the generating plant would have to be connected into the existing power distribution network.

For a water cooled steam generating plant, large volumes of water and water rights would have to be obtained and pipelines and storage facilities build to supply the plant. The electrical generating stations in the areas of consumption would lose the supply of coal for which they were designed unless coal of like quality from another mine in the area was substituted for the coal from the Belle Ayr South Mine.

The local environmental impacts that would result from onsite power generation would be degradation of air quality by stack emissions; land use problems related to ash disposal; noise from the generating station; diversion of the large quantity of water needed from other uses; degradation of scenery by the generating station, transmission lines, and support facilities; dust related to coal handling; processing and ash disposal; loss of land used by the generating station and support facilities from other uses; and increased employment and related economic benefits. Impacts associated with mining and reclamation would remain the same.

Other offsite markets

To supply coal to other offsite electrical power generating plants would have the effect of transferring transportation and other end use impacts elsewhere. The impacts associated with mining and reclamation would remain the same if the proposed production rate was not increased. If increased, the severity of these would also be increased.

Non-energy uses for the coal

Coal is used by the chemical industry in the manufacture of synthetic materials and has been used as a soil conditioner which, when mixed with topsoil, darkens the soil, absorbs heat, and stimulates plant growth. Some types of lignite have been used in oil drilling muds, in water treatment, and in wood stains. The coal at the Belle Ayr South Mine is subbituminous and is not suitable for the latter uses but could be used by the chemical and soil conditioner industries, depending on its properties. If coal production were not increased, the impacts of mining and reclamation would remain the same. If the coal were used exclusively by the chemical and soil conditioner industries, the power plants dependent on the coal would have to locate substitute sources of fuel.

CHAPTER IX

CONSULTATION AND COORDINATION WITH OTHERS

Development of Statement

This Environmental Impact Statement covers an operation which is an integral part of the development of coal resources in the eastern Powder River Coal Basin of Wyoming.

A large amount of data was gathered and analyzed by the Department of the Interior in the preparation of the Final Environmental Impact Statement on that development (FES 74-55) and a large number of agencies and groups participated.

Insofar as their analyses and data were used in part to prepare this statement all of the people, groups and agencies listed on pages I-877 and I-878 of FES 74-55 also aided in the preparation of this statement. Public comments received and the results of public hearings held during the preparation of FES 74-55 were considered in the preparation of the present draft statement.

Direct input of data and assistance was provided by the Bureau of Land Management, Department of the Interior, for the preparation of this specific draft environmental statement.

Review of Statement

In accordance with the CEQ guidelines, copies of this statement are available to the public for their comments and suggestions. In addition, comments have been solicited from the following governmental organizations:

- Environmental Protection Agency
- United States Department of the Interior
  - Bureau of Indian Affairs
  - Bureau of Land Management
  - Bureau of Mines
  - Bureau of Outdoor Recreation
  - Bureau of Reclamation
  - Fish and Wildlife Service
  - National Park Service
  - Office of Coal Research
- United States Department of Agriculture
  - Forest Service
  - Soil Conservation Service
- Federal Power Commission
- Federal Energy Agency
- United States Department of Health, Education and Welfare
- Interstate Commerce Commission
- Department of Transportation
- State of Wyoming
  - Governors Clearing House
  - State Historic Preservation Officer
- Board of County Commissioners of
  - Campbell County
  - Converse County

GLOSSARY

AASHO classification (soil engineering). The official classification of soil materials and soil aggregate mixtures for highway construction used by the American Association of State Highway Officials.

Acre-foot. The quantity of a material that will cover 1 acre of land 1 foot deep.

Aestivate. To pass the summer in a dormant state. Summertime hibernation.

Agglomerate. To fuse into a mass.

Alkaline soil. Precisely, any soil horizon having a pH value greater than 7.0; practically, a soil having a pH above 7.3.

Alkali soil. 1: A soil with a high degree of alkalinity (pH of 8.5 or higher) or with a high exchangeable sodium content (15 percent or more of the exchange capacity) or both. 2: A soil that contains sufficient alkali (sodium) to interfere with the growth of most crop plants.

Alluvial soils. An azonal great soil group developed from transported and relatively recently deposited material (alluvium) characterized by a weak modification (or none) of the original material by soil-forming processes.

Alluvium. Clay, silt, sand, and gravel or other rock material transported by flowing water and deposited as sorted or semi-sorted sediments.

Ammonium nitrite fuel-oil prill. A globular, porous particle obtained by spraying ammonium nitrate and fuel oil in a rising current of warm air. Used in blasting.

Angle of repose. Angle between the horizontal and the maximum slope that a soil assumes through natural processes.

Animal unit month. A measure of forage or feed requirement to maintain one animal (cow or 5 sheep) for a period of 30 days. Abbreviated: AUM.

Annual plant. A plant that completes its life cycle and dies in one year or less.

Aquifer. A layer of rock, sand, or gravel that contains water and that will deliver it in usable quantities to wells.

Aquifer skeleton. The mineral framework of a water-bearing zone or aquifer.

Atmospheric stability. The degree of vertical mixing of the air. It is a measure of the potential ability of air to diffuse pollutants both laterally and vertically.

Available water-holding capacity (soils). The capacity to store water available for use by plants, usually expressed in linear depths of water per unit depth of soil.

Backfill. The process of filling, or the material used to fill, a surface mine pit.

Bedrock. The more or less solid rock in place either on or beneath the surface of the earth.

Belt conveyor. A moving, endless belt that rides on rollers and on which materials can be carried for various distances.

Belt line. A belt conveyor.

Bench. A division of a coalbed. A layer in a coalbed mined separately.

Biome. A major biotic unit consisting of plant and animal communities having similarities in form and environmental conditions.

Boxcut. The initial pit in a strip mine where no open side exists; this results in a highwall on both sides of the pit.

Breaks. Rough, broken topography--in many places the transition area between highlands and lowlands.

Browse. That part of leaf and twig growth of shrubs, woody vines, and trees available for animal consumption.

Btu. Abbreviation for the British thermal unit. Amount of heat needed to raise 1 pound of water 1 degree F (252 calories).

Burn area. Area of clinker.

Burnline. Rock outcrop of hard clinker produced by a burning coalbed.

Carbonaceous. Containing carbon. Shale or other rock containing small fragments of carbon distributed throughout.

Carnivorous. Flesh eating.

Carrying capacity. A maximum number of animals that can survive on a land area over the long term.

Channery. Soil mass containing between 15 and 90 percent by volume of fragments.

Claystone. Hardened clay.

Clinker. Natural baked shale--in the study area it normally overlies burned out coal seams and was formed by burning of the coal. Locally called scoria.

Coal. A solid, brittle, dark brown to black, combustible, carbonaceous rock formed by the partial to complete decomposition of vegetation.

Coal slack. Fine-grained coal resulting from weathering and exposure to air.

Coke. Coal from which volatile constituents have been driven off by heat, so that the fixed carbon and ash are fused together.

Colluvium. Loose, unconsolidated clay, silt, sand, and gravel at the foot of a slope, brought there by force of gravity.

Community. An aggregate of organisms which form a distinct ecological unit. Such a unit may be defined in terms of plants, animals, or both.

Concretion. An accumulation of mineral matter cemented around a center within a sedimentary host rock, commonly spheroidal or disk-shaped.

Contour furrows. Furrows plowed approximately on the contour on pasture or rangeland to prevent soil loss and increase infiltration. Also, furrows laid out approximately on the contour for irrigation purposes.

Corrosion (of rock). The solution of rocks and other materials by chemical action.

Coulee. A steep-walled valley or ravine varying widely in size and often having a stream at the bottom.

Crop out. To be exposed at the surface.

Cover, vegetative. All plants found on an area, irrespective of whether they have forage or other value. Syn.: plant cover.

Dip. The angle at which a bed or stream is inclined from the horizontal.

Discharge. The process by which water moves from an aquifer, or the amount of water that moves from an aquifer.

Dissolved solids. The total dissolved mineral constituents of water.

Diversion terrace. Channels across a hillside used to protect bottomland from hillside runoff or to protect against runoff from an unterraced area.

Dragline. A type of excavating equipment which casts a rope-hung bucket and collects dug material by pulling the bucket with a second rope.

Dry farming. Farming without irrigation.

Ecology. A study of animals and plants in their relation to each other and to their environment.

Ecosystem. Complex self-sustaining natural system which includes living and nonliving components of the environment and the interactions that bind them together. Its functioning involves the circulation of matter and energy between organisms and their environment.

Ecotone. Transition zone between two adjacent plant or animal communities.

Ecotype. A locally adapted population of a species which has a distinctive limit of tolerance to environmental factors.

Effluent. A liquid or gaseous product discharged from the ground, or a process.

Eolian soil material. Soil material accumulated through wind action.

Erodible. Susceptible to erosion. (Expressed by terms such as highly erodible, slightly erodible, etc.)

Exotic. Not native, usually from another continent.

Fauna. The animals of a particular period or region taken collectively.

Final highwall. The final face of exposed overburden and coal or ore in a surface mine.

Flow net. A graphic representation of the flow lines and equipotential lines used in the study of seepage.

Food chain. The pattern of energy or food transfer between a series of organisms interrelated in their feeding habits within an ecosystem. One organism is fed upon by another which in turn is fed upon by another, etc.

Forb. Any herbacious plant other than those that are grass or grass-like.

Formation. A distinctive group of rocks selected as a convenient unit for mapping, description, and reference.

Friable. Easy to break, crumbling naturally, poorly cemented so as to crumble.

Geomorphology. That branch of both physiography and geology that deals with the form of the earth, the general configuration of its surface, and the changes that take place in the evolution of landforms.

gpd. Gallons per day.

gpm. Gallons per minute.

Ground water. Atmospheric water which saturates rock openings at and beneath the water table. Also used to mean all water below the ground surface.

Habitat. A specific set of physical conditions that surround the single species, a group of species, or a large community. In wildlife management, the major components of habitat are considered to be food, water, cover, and living space.

Herbivorous. Plant eating.

Highwall. The unexcavated face of exposed overburden and coal in a strip mine pit.

Hydrophyte. A plant that grows in water on in wet or saturated soils.

Infrastructure. Those public services and facilities necessary for the existence of a town and normally supported by public funds, such as schools, roads, medical services and facilities.

Insectivorous. Insect eating.

Intermittent stream. A stream that flows only part of the time.

Invertebrate. An animal without a backbone. This group includes such animals as insects, clams, snails, worms, and others.

Isogram. A line connecting points of equal value with regard to certain variables.

Isopach. A line connecting points of equal or corresponding thickness.

Isopleth. A line connecting points of equal or corresponding values with regard to certain chemical elements.

Landform. A discernible natural landscape, such as a floodplain, stream terrace, plateau, valley, etc.

Lignite. A brownish-black coal in which the alteration of vegetable material has not progressed as far as subbituminous coal.

Limiting factor. A critical living or nonliving element of an ecosystem necessary for an organism to survive that is in the least supply.

Long ton. A unit of weight that equals 2,240 pounds.

Member. A division of a formation generally of distinct lithology.

Mesophyte. A plant that grows under intermediate moisture conditions.

Mg/1. Abbreviation for milligrams per liter, the unit of expression for the concentration of dissolved minerals in water.

Miscellaneous land type. Areas of land that have little or no natural soil or that are too nearly inaccessible for orderly examination or that occur where, for other reasons, it is not feasible to classify the soil.

Mixing height. Thickness of the mixing layer (see below).

Mixing layer. In air pollution terminology, the layer of air, usually a subinversion layer, within which pollutants are mixed by turbulance and diffusion.

Mollusks. An invertebrate group which includes snails, clams, chitins, and others.

Nonagglomerating. Will not agglomerate.

Noncoking . Will not coke.

Opencast method. A mining method which consists in removing the overlying rock or overburden, extracting the coal, and then replacing the overburden.

Overburden. Rock or unconsolidated material overlying a coalbed, excavated during strip mining.

Parting. A band of waste material dividing the coal layers.

Passerine. Small or medium sized, chiefly perching song birds, having grasping feet with the first toe directed backwards.

Perennial. Having a life cycle that lasts more than two years.

Perennial stream. A stream that flows all the time.

Permeability, soil. The quality of a soil horizon that enable water or air to move through it.

Physical properties (of soils). Those characteristics, processes, or reactions of a soil which are caused by physical forces and which can be described by, or expressed in, physical terms or equations.

Playa. A shallow central basin of a plain where water gathers after a rain and is evaporated.

Porosity. The ratio of void volume to total volume of a porous medium.

Potentiometric surface. An imaginary surface that coincides with the static level of water in an aquifer.

Prill. A globular, porous particle obtained by spraying a solution of ammonium nitrate into a rising current of warm air.

Proximate analysis. The determination of the compounds in a coal.

R. Range, one of the north-south rows of townships in a U.S. public-land survey.

Rank. The place occupied by a coal in a classification. A term used to indicate the position of a coal in the series peat to anthracite.

Raptorial. An order of birds including all the birds of prey such as the eagle, hawk, owl, and vulture.

Recharge. The process by which water moves into an aquifer, or the amount of water that moves into an aquifer.

Reclamation. Restoration of mined or disturbed land; rehabilitation.

Rehabilitation. Restoration of mined or disturbed land; reclamation.

Reserves. Known deposits of coal that can be profitably mined. Tonnage generally known within 20 percent.

Resources. Includes reserves and other coal deposits that may become profitable to mine. Tonnage imperfectly known.

Riparian. Situated on or pertaining to the bank of a river, stream, or other body of water.

Road metal. Rock suitable for surfacing dirt and macadamized roads and for foundations for asphalt and concrete roadways.

Rough broken land. Land with very steep topography and numerous intermittent drainage channels but usually covered with vegetation.

Rs. Plural of range.

Saline-alkali soil. A soil containing sufficient exchangeable sodium to interfere with the growth of most crop plants and containing appreciable quantities of soluble salts.

Saline soil. A nonalkali soil containing sufficient soluble salts to impair its productivity but not containing excessive exchangeable sodium.

Sandstone. A cemented or compacted sedimentary rock composed usually of grains of quartz.

Scarified. The breaking with a machine of hard soil material or spoil in strip mine reclamation.

Scoria. Local term for natural baked shale--see "clinker."

Scoria land. Areas of slaglike clinkers, burned shale, and fine-grained sandstone; characteristic of burned-out coalbeds.

Sec. A parcel of land that is 1 square mile or 640 acres. Known as a section.

Secs. Plural of sec. or section.

Semiarid. A term applied to regions or climates where moisture is normally greater than under arid conditions but still definitely limits the growth of most crops.

Shale. A fine-grained sedimentary rock.

Shale parting. A layer of shale separating benches of coal.

Short ton. A unit of weight that equals 2,000 pounds.

Siltstone. A sedimentary rock composed of grains intermediate in size between clay and sand.

Slope wash. Soil and rock material that has been moved down a slope by gravity and running water and not concentrated in a channel.

Slurry. A mixture of fine coal in water. Commonly pumped through pipelines at processing plants or to consumption points.

Soil association. A group of defined and named soil units occurring together in an individual and characteristic pattern over a geographic region, comparable to plant associations in many ways.

Soil material. Soils leached free of soluble salts and capable of sustaining plant growth and recognized as such by standard authorities.

Soil series. A group of soils having horizons similar in characteristics and arrangement in the soil profile, except for texture of the surface portion.

Solute. A substance dissolved in a solution, as distinguished from the solvent.

Spoil. The overburden removed in strip mining. Debris or waste material from a strip mine.

Stagnation episode. Meterological conditions, generally temperature inversions, lasting from two to five days during which air pollutant concentrations increase, resulting in one or more of the following effects: reduced visibility, damage to vegetation and animals, coughing and eye irritation, increased morbidity, and increased mortality.

Storage coefficient. For an aquifer, the volume of water released from storage in a vertical column of 1.0 square feet when the water table or other piezometric surface declines 1.0 foot.

Subbituminous coal. Nonagglomerating coal having a heat value of 8,300 to 13,000 Btu on a moist, mineral-matter-free basis. Intermediate in rank between lignite and bituminous coal.

Succession. The progressive development of vegetation toward its highest ecological expression, the climax; replacement of one plant community by another.

T. Township, a tract of land that is bounded on the east and west by meridians six miles apart at its south border, has a north-south length of six miles, and forms one of the chief divisions of a U.S. public-land survey.

Temperature inversion. A layer in which temperature increases with altitude. The principal characteristic of an inversion layer is its marked static stability, within which very little turbulent exchange can occur.

Terrace. An embankment or combination of an embankment and channel constructed across a slope to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down the slope.

Throwing radius. The radius through which a dragline can dig, rotate, and deposit material. It is dependent on the length of the dragline's boom.

Topsoil. As used for mined area spoil reclamation, topsoil refers to the A horizons, and those portions of the B and C horizons, that are favorable for the growth of plants. For the railroad right-of-way, it refers to the A horizons only.

Tps. Townships.

Transmissivity. In an aquifer, the rate at which water of the prevailing kinematic viscosity is transmitted through a unit width under a unit dydraulic gradient.

Transpiration. The process by which water moves from living plants to the atmosphere.

Ultimate analysis. The determination of the percentage of constituent elements of a chemical substance such as coal.

Unified Soil Classification System (engineering). A classification system based on the identification of soils according to their particle size, gradation, plasticity index, and liquid limit.

Unit train. A train made up entirely of coal cars carrying coal directly from the loading place to point of delivery.

Upland. An extensive region of highland in the interior of the country; higher land in contrast to valley, plain, or other low-lying land; a plateau.

Vertebrate. All animals having a segmented spinal column.

Water table. Generally considered to be near the top of the zone of saturation in an unconfined aquifer, but this water level in a well may fluctuate in response to several factors.

Wind rose. A diagram designed to show the distribution of wind direction recorded at a given location over a period of time.

Working pit. The place at a mine from which coal is actually being extracted.

SELECTED BIBLIOGRAPHY

Amax Coal Company. 1974. Environmental Report and Proposed Plan of Mining and Reclamation, Belle Ayr South Mine, Coal Lease W-0317682, Campbell County, Wyoming. January 9, 1974.

__________. 1974. Miscellaneous Reports from Amax Continuing Environmental Research studies.

American Society for Testing Materials. 1939.

Baxter, George T. and Simon, James R. 1970. Fishes of Wyoming. Bulletin No. 2. Cheyenne: Wyoming Game and Fish Department.

Curry, W. H. III. 1971. Laramide Structural History of the Powder River Basin, Wyoming. Guidebook, 23rd Annual Field Conference - 1971. Wyoming Geological Association.

Dexter, D. 1974. State Fish Warden. Wyoming Game and Fish Department, Cheyenne. Correspondence, January 1974.

Einarsen, A. S. 1948. The Pronghorn Antelope and Its Management. The Wildlife Management Institute, Washington, D. C.

Environmental Protection Agency. 1970. Water Quality Criteria Data Book, Organic Chemical Pollution of Freshwater. Water Pollution Control Research Series, Vol. 1.

__________. 1973. Compilation of Air Pollutant Emission Factors. Publication No. AP-42. April 1973.

__________. 1974. Report of the Hearing Panel--National Public Hearing on Power Plant Compliance with Sulfur Oxide Air Pollution Regulations. January 1974.

Federal Water Pollution Control Administration 1968. Water Quality Criteria. Washington, D. C.: Report of the National Technical Advisory Committee on Water Quality Criteria.

Fenneman, Nevin M. 1931. Physiography of Western United States. New York: McGraw-Hill.

Fleischer, M.; Sarofim, A. F.; Fassett, D. W.; Hammond, P.; Shacklette, H. T.; Nisbet, I. C. T.; and Epstein S. 1974. Environmental Impact of Cadmium. A review by the panel on hazardous trace substances. Environmental Health Perspectives.

Frison, George, Dr. 1974. Department of Anthropology, University of Wyoming. Personal communication, March 1974.

Hodson, Warren G. 1971. Chemical Analyses of Ground Water in the Powder River Basin and Adjacent Areas, Northeastern Wyoming. Wyoming Department of Economic Planning and Development.

Hoover, R. L.; Till, C. E.; and Ogilvie, S. 1959. The Antelope of Colorado. Denver: Colorado Game and Fish Department.

Leggett, R. F. 1939. Geology and Engineering. New York: McGraw-Hill.

Lowham, H. W. 1975. Techniques for Estimating Flow Characteristics of Wyoming Streams. U.S. Geological Survey open-file report. (In preparation.)

Magee, E. M.; Hall, H. J.; and Varga, G. M., Jr. 1973. Potential Pollutants in Fossil Fuels. EPA-R2-73-249. Prepared for U.S. Environmental Protection Agency by ESSO Research and Engineering Co.

Martin, A. C.; Zim, H. S.; and Nelson, A. L. 1951. American Wildlife and Plants. New York: McGraw Hill. (Paperback: New York: Dover Publications, 1961.)

McKee, J. E. and Wolf, Harold W. 1963. Water Quality Criteria. Publication No. 3-A (second edition). The Resources Agency of California, State Water Resources Control Board.

McTernan, William F. 1974. The Bacteriological and Chemical Examination of Waters Associated with a Surface Coal Mine in Northeastern Wyoming: Laramie, University of Wyoming, May 1974.

National Academy of Sciences. 1971. Selenium in Nutrition. Washington, D. C.: Subcommittee on Selenium, National Research Council.

__________. 1973. Water Quality Criteria. EPA-R3-73-033. Environmental Studies Board, National Academy of Engineering. December 1973.

__________. 1974. Vanadium. Medical and Biological Effects of Environmental Pollutants. Washington, D. C.: Committee on Biologic Effects of Atmospheric Pollutants, National Research Council.

O'Gormon, J. Y. and Walker, P. L., Jr. 1972. Mineral Matter and Trace Elements in U.S. Coals. U.S. Department of the Interior, Office of Coal Research, Research and Development Report No. 61 (Interim Rep. No. 2).

Osterwald, F. W. 1974. Environmental Geologic Aspects of a Proposed North-South Railroad in the Eastern Powder River Basin, Wyoming. Unpublished.

Penz, M. 1975. The Effects of Strip Mining of Coal on Shallow Groundwater aquifers in the Eastern Powder River Basin of Wyoming, Thesis: Laramie, University of Wyoming (in preparation).

Rechard, P. A.; Hasfurther, M.; Penz, M. 1974. Hydrology Section: Environmental Basline Study for Amax Belle Ayr Mine.

Severson, K. E. 1966. Grazing and Competition of Pronghorn Antelope and Domestic Sheep in Wyoming's Red Desert. Ph.D. Thesis. Laramie: University of Wyoming.

Sherman, William F. 1974. Wyoming Highway Department. Written Communication.

Swanson, V. E. 1972. Composition and Trace-Element Content of Coal and Power Plant Ash. Pt. 2, Appendix J. Southwest Energy Study. U.S. Geological Survey open-file report.

Underwood, E. J. 1971. Trace Elements in Human and Animal Nutrition. New York: Academic Press.

U.S. Department of Agriculture. Soil Conservation Service. 1955. Reconnaissance Soil Survey of Campbell County, Wyoming.

U.S. Department of Health, Education and Welfare. 1969. Air Quality Criteria for Sulfur Oxides. January 1969.

U.S. Department of the Interior. Bureau of Sport Fisheries and Wildlife. 1972. Office of Endangered Species and International Activities. Threatened Wildlife of the United States. Resource Publication 114. Washington, D. C.: Government Printing Office.

USDI Geological Survey. 1908. The Powder River Coal Field, Wyoming, Adjacent to the Burlington Railroad, by R. W. Stone and C. T. Lupton. Geological Survey Bulletin 381.

__________. 1927. The Gillette Coal Field Northeastern Wyoming (with a chapter on the Minturn district and the northeastern part of the Gillette Field by W. T. Thom, Jr.), by C. E. Dobbin and V. H. Barnett. Geological Survey Bulletin 796-A.

__________. 1958. A Reconnaissance of the Sand and Gravel Deposits of Wyoming, by G. M. Richmond, J. H. Cattermole, P. E. Truesdell, and F. W. Foster. Geological Survey open-file report.

__________. 1958a. Uranium Deposits and Principal Ore-Bearing Formations of the Central Cordilleran Foreland Region. Geological Survey Miscellaneous Field Studies Map MF-120.

__________. 1961. Relation of Uranium Deposits to Tectonic Pattern of the Central Cordilleran Foreland, by F. W. Osterwald and B. G. Dean. Geological Survey Bulletin 1087-I.

__________. 1961a. Hydrology of Stock-Water Reservoirs in Upper Cheyenne River Basin, by R. C. Culler, Geological Survey Water Supply Paper 1531-A. Washington, D. C.: Government Printing Office.

__________. 1964. Stratigraphy and Structure of the Northern and Western Flanks of the Black Hills Uplift, Wyoming, Montana, and South Dakota. Geological Survey Professional Paper 404.

__________. 1972. Geologic Map of Tertiary and Uppermost Cretaceous Rocks Showing Structure Contours, Oil and Gas Fields, Dry Holes, and Mines in the Southern Park of the Powder River Basin, Converse, Niobrara and Natrona Counties, Wyoming, by N. M. Denson and G. H. Horn. Geological Survey open-file map.

__________. 1973. Coal Resources of the Gillette Area, Wyoming, by N. M. Denson, W. R. Keefer, and G. H. Horn. Geological Survey Miscellaneous Geological Inventory Map I-848-C.

U.S. Public Health Service. 1962. Drinking Water Standards. Publication No. 956. Washington, D. C.: Government Printing Office.

Williams, Bob. 1974. Wyoming Game and Fish Department. Sheridan, Wyoming. Interview, March 11, 1974.

World Health Organization. 1971. International Standards for Drinking Water. Geneva, Switzerland.

Wyoming Game and Fish Department. 1972a. 1971 Antelope, Deer and Elk Population Studies, by R. W. Wilson, Cheyenne: Wyoming Game and Fish.

__________. 1972b. Annual Report of Big Game Harvest, 1971. Cheyenne: Wyoming Game and Fish.

__________. 1973. Annual Report of Big Game Harvest, 1972. Cheyenne: Wyoming Game and Fish.

__________. Forthcoming. Annual Report of Big Game Harvest, 1973. Cheyenne: Wyoming Game and Fish.

Wyoming State Highway Commission. 1972. Twenty-eighth Biennial Report, June 30, 1972.

Zubovic, Peter; Stadnichenko, Taisia; and Sheffey, N. B. 1961. Geochemistry of Minor Elements in Coals of the Northern Great Plains Province. U.S. Geological Survey Bulletin 1117-A.

APPENDIX A

Copy of Coal Lease
W-0317682

Form 4-696
(January 1964)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

COAL LEASE

Land Office
WYOMING

Serial Number
Wyoming 0317682

AUG 1 1965
ROCK SPRINGS, WYOMING

This lease, entered into on the 1st day of September, 1965, by the United States of America, the lessor, through the Bureau of Land Management, and

Ayrshire Collieries Corporation
430 Big Four Building
105 South Meridian Street
Indianapolis, Indiana 46225

U. S. GEOLOGICAL SURVEY
AUG 18 '65
RECEIVED
BILLINGS, MONTANA

, the lessee, pursuant and subject to the terms and provisions of the Act of February 25, 1920 (41 Stat. 437), as amended, hereinafter referred to as the Act, and to all reasonable regulations of the Secretary of the Interior now or hereafter in force which are made a part hereof,

WITNESSETH:

Sec. 1. *Rights of Lessee.* The lessor, in consideration of the rents and royalties to be paid and the conditions to be observed as hereinafter set forth does hereby grant and lease to the lessee the exclusive right and privilege to mine and dispose of all the coal in the following-described tracts of land, situated in the State of Wyoming

T. 47 N., R. 71 W., 6th Prin. Mer.
Section 3: Lots 1, 2, 3, 4
Section 4: Lots 1, 2, 3, 4
Section 5: Lots 1, 2

T. 48 N., R. 71 W., 6th Prin. Mer.
Section 26: NW¼, W½SW¼
Section 27: S½
Section 28: S½
Section 29: SE¼
Section 32: N½NE¼, SW¼NE¼, N½SW¼, NW¼SE¼, SE¼SE¼
Section 33: NW¼NE¼, N½NW¼, W½SW¼, SE¼SW¼, SW¼SE¼, E½SE¼
Section 34: N½NE¼, ~~[illegible]~~, SW¼, W½SE¼
NE¼NW¼

containing 2440.31 acres, more or less, together with the right to construct all such works, buildings, plants, structures, and appliances as may be necessary and convenient for the mining and preparation of the coal for market, the manufacture of coke or other products of coal, the housing and welfare of employees, and subject to the conditions herein provided, to use so much of the surface as may reasonably be required in the exercise of the rights and privileges herein granted.

Sec. 2. In consideration of the foregoing, the lessee hereby agrees:

(a) Bond. To maintain the bond furnished upon the issuance of this lease, which bond is conditioned upon compliance with all the provisions of the lease, and to increase the amount or furnish such other bond as may be required.

(b) Rental. To pay the lessor annually, in advance, for each acre or fraction thereof covered by this lease, beginning with the date hereof, the following rentals: 25 cents for the first year; 50 cents for the second, third, fourth, and fifth years, respectively; and $1 for the sixth and each succeeding year during the continuance of the lease, such rental for any year to be credited against the first royalties as they accrue under the lease during the year for which the rental was paid.

(c) Royalty. To pay the lessor a royalty of cents on every ton of 2,000 pounds of coal mined during the first 20 years succeeding the execution of this lease. Royalties shall be payable quarterly within 30 days from the expiration of the quarter in which the coal is mined. For additional royalty terms, see last page.

(d) Minimum production. Beginning with the sixth year of the lease, *except* when operations are interrupted by strikes, the elements, or casualties not attributable to the lessee, or unless on application and showing made, operations shall be suspended when market conditions are such that the lessee cannot operate *except* at a loss or suspended for the other reasons specified in Section 39 of the Act, to mine coal each year and pay a royalty thereon to a value of $1 per acre or fraction thereof. Operations under this lease shall be continuous *except* in circumstances described or unless the lessee shall pay a royalty, less rent, on such minimum amount of the leased deposits, for one year in advance, in which case operations may be suspended for that year.

(e) Payments. To make rental payments to the Manager of the appropriate Land Office, *except* that when this lease becomes productive the rentals and

royalties shall be paid to the appropriate Regional Mining Supervisor of the United States Geological Survey, with whom all reports concerning operations under the lease shall be filed. All remittances to the Manager of the Land Office shall be made payable to the Bureau of Land Management, those to the Geological Survey shall be made payable to the United States Geological Survey.

(f) Plats, reports, maps. At such times and in such form as the lessor may prescribe, to furnish a plat showing development work and improvements on the leased lands and a report with respect to stockholders, investment, depreciation, and costs. To furnish in such form as the lessor may prescribe, within 30 days from the expiration of each quarter a report covering such quarter, certified by the superintendent of the mine, or by such other agent having personal knowledge of the facts as may be designated by the lessee for such purpose, showing the amount of leased deposits mined during the quarter, the character and quality thereof, amount of its products and byproducts disposed of and price received therefor, and amount in storage or held for sale. To keep and prepare maps of the leased lands in accordance with the appropriate regulations.

(g) Weights. To determine accurately the weight or quantity and quality of all leased deposits mined, and to enter accurately the weight or quantity and quality thereof in due form in books to be kept and preserved by the lessee for such purposes.

(h) Inspection. To permit at all reasonable times (1) inspection by any duly authorized officer of the Department, of the leased premises and all surface and underground improvements, works, machinery, equipment, and all books and records pertaining to operations and surveys or investigations under this lease; and (2) the lessor to make copies of and extracts from any or all books and records pertaining to operations under this lease, if desired.

(i) Assignment. To file for approval in the appropriate Land Office within 90 days from the date of execution, any assignment or transfer made of this lease, whether by direct assignment, operating agreement, working or royalty interest, or otherwise. Such instrument will take effect the first day of the month following its approval by the Bureau of Land Management, or if the assignee requests, the first day of the month of approval. The showing required to be made with an assignment or transfer is set forth in the appropriate regulations.

(j) Nondiscrimination clauses. During the performance of this contract the lessee agrees as follows:

(1) The lessee will not discriminate against any employee or applicant for employment because of race, creed, color, or national origin. The lessee will take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, creed, color, or national origin. Such action shall include, but not be limited to, the following: employment, upgrading, demotion or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The lessee agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the contracting officer setting forth the provisions of this nondiscrimination clause.

(2) The lessee will, in all solicitations or advertisements for employees placed by or on behalf of the lessee, state that all qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

(3) The lessee will send to each labor union or representative of workers with which he has a collective bargaining agreement or other contract or understanding, a notice, to be provided by the agency contracting officer, advising the said labor union or workers' representative of the lessee's commitments under this section, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

(4) The lessee will comply with all provisions of Executive Order No. 10925 of March 6, 1961, as amended, and of the rules, regulations, and relevant orders of the President's Committee on Equal Employment Opportunity created thereby.

(5) The lessee will furnish all information and reports required by Executive Order No. 10925 of March 6, 1961, as amended, and by the rules, regulations, and orders of the said Committee, or pursuant thereto, and will permit access to his books, records, and accounts by the contracting agency and the Committee for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

(6) In the event of the lessee's noncompliance with the nondiscrimination clauses of this contract or with any of the said rules, regulations, or orders, this lease may be cancelled, terminated, or suspended in whole or in part and the lessee may be declared ineligible for further Government contracts in accordance with procedures authorized in Executive Order No. 10925 of March 6, 1961, as amended, and such other sanctions may be imposed and remedies invoked as provided in the said Executive Order or by rule, regulation, or order of the President's Committee on Equal Employment Opportunity, or as otherwise provided by law.

(7) The lessee will include the provisions of paragraphs (1) through (7) in every subcontract or purchase order unless exempted by rules, regulations, or orders of the President's Committee on Equal Employment Opportunity issued pursuant to Section 303 of Executive Order No. 10925 of March 6, 1961, as amended, so that such provisions will be binding upon each subcontractor or vendor. The lessee will take such action with respect to any subcontract or purchase order as the contracting agency may direct as a means of enforcing such provisions, including sanctions for noncompliance: *Provided, however,* that in the event the lessee becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of such direction by the contracting agency, the lessee may request the United States to enter into such litigation to protect the interests of the United States.

(k) Land disposed of with coal deposits reserved to the United States. If the lands embraced herein have been or shall hereafter be disposed of under laws reserving to the United States the deposits of coal therein, to comply with all conditions as are or may hereafter be provided by the laws and regulations reserving such coal.

(l) Operations, wages, freedom of purchase. To comply with the appropriate operating regulations, to exercise reasonable diligence, skill, and care in the operations of the property, and to carry on all operations in accordance with approved methods and practices as provided in the operating regulations, having due regard for the prevention of injury to life, health or property, and of waste or damage to any water or mineral deposits; to fairly and justly weigh or measure the coal mined by each miner, to pay all wages due miners and employees, both above and below ground, at least twice each month in lawful money of the United States; to accord all miners and employees complete freedom of purchase; to restrict the workday to not exceeding eight [illegible] in any one day for underground

workers, except in cases of er[illegible]; to employ no boy under the age of sixteen and no girl or woman, without regard to age, in any mine below the surface; unless the laws of the State otherwise provide, in which case the State laws control.

(m) Taxes. To pay when due, all taxes lawfully assessed and levied under the laws of the State or the United States upon improvements, output of mines, or other rights, property, or assets of the lessee.

(n) Overriding royalties. Not to create, by assignment or otherwise, an overriding royalty interest in excess of 50 percent of the rate of royalty first payable to the United States under this lease or an overriding royalty interest which when added to any other outstanding overriding royalty interest exceeds that percentage, excepting, that where an interest in the leasehold or in an operating agreement is assigned, the assignor may retain an overriding royalty interest in excess of the above limitation if he shows to the satisfaction of the Bureau of Land Management, that he has made substantial investments for improvements on the land covered by the assignment.

(o) Delivery of premises in case of forfeiture. In case of forfeiture of this lease, to deliver up to the lessor in good order and condition the land leased, including all buildings, and underground timbering and such other supports and structures as are necessary for the preservation of the mine or deposit.

Sec. 3. The lessor expressly reserves:

(a) Rights reserved. The right to permit for joint or several use such easements or rights-of-way, including easements in tunnels upon, through, or in the land leased, occupied, or used as may be necessary or appropriate to the working of the same or other lands containing the deposits described in the Act, and the treatment and shipment of the products thereof by or under authority of the Government, its lessees or permittees, and for other public purposes.

(b) Disposition of surface. The right to lease, sell, or otherwise dispose of the surface of the leased lands under existing law or laws hereafter enacted, insofar as said surface is not necessary for the use of the lessee in the extraction and removal of the coal therein, or to dispose of any resource in such lands which will not unreasonably interfere with operations under this lease.

(c) Monopoly and fair prices. Full power and authority to promulgate and enforce all the provisions of Section 30 of the Act to insure the sale of the production of said leased lands to the United States and to the public at reasonable prices, to prevent monopoly, and to safeguard the public welfare.

(d) Readjustment of terms. The right reasonably to readjust and fix royalties payable hereunder and other terms and conditions at the end of 20 years from the date hereof and thereafter at the end of each succeeding 20-year period during the continuance of this lease unless otherwise provided by law at the time of the expiration of any such period. Unless the lessee files objections to the proposed terms or a relinquishment of the lease within 30 days after receipt of the notice of proposed terms for a 20-year period, he will be deemed to have agreed to such terms.

(e) Waiver of conditions. The right to waive any breach of the conditions contained herein, *except* the breach of such conditions as are required by the Act, but any such waiver shall extend only to the particular breach so waived and shall not limit the rights of the lessor with resp[illegible] any future breach; nor shall the waiver of a particular cause of forfeiture prevent cancellation of this lease for any other cause, or for the same cause occurring at another time.

Sec. 4. *Relinquishment of lease.* Upon a satisfactory showing that the public interest will not be impaired, the lessee may surrender the entire lease or any legal subdivision thereof. A relinquishment *must* be filed in *duplicate* in the appropriate Land Office. Upon its acceptance it shall be effective as of the date it is filed, subject to the continued obligation of the lessee and his surety to make payment of all accrued rentals and royalties and to provide for the preservation of any mines or productive works or permanent improvements on the leased lands in accordance with the regulations and terms of the lease.

Sec. 5. *Protection of the surface, natural resources, and improvements.* The lessee agrees to take such reasonable steps as may be needed to prevent operations from unnecessarily: (1) causing or contributing to soil erosion or damaging any forage and timber growth thereon; (2) polluting the waters of springs, streams, wells, or reservoirs; (3) damaging crops, including forage, timber, or improvements of a surface owner; or (4) damaging range improvements whether owned by the United States or by its grazing permittees or lessees; and upon any partial or total relinquishment or the cancellation or expiration of this lease, or at any other time prior thereto when required by the lessor and to the extent deemed necessary by the lessor, to fill any sump holes, ditches and other excavations, remove or cover all debris, and, so far as reasonably possible, restore the surface of the leased land to its former condition, including the removal of structures as and if required. The lessor may prescribe the steps to be taken and restoration to be made with respect to lands of the United States and improvements thereon.

Sec. 6. *Removal of equipment, etc., on termination of lease.* Upon termination of this lease, by surrender or forfeiture, the lessee shall have the privilege at any time within a period of 90 days thereafter of removing from the premises all machinery, equipment, tools and materials, *except* underground timbering placed by the lessee in or on the leased lands, which are necessary for the preservation of the mine. Any materials, tools, appliances, machinery, structures, and equipment, subject to removal as above provided, which are allowed to remain on the leased lands shall become the property of the lessor on expiration of the 90-day period or such extension thereof as may be granted because of adverse climatic conditions, but the lessee shall remove any or all of such property where so directed by the lessor.

Sec. 7. *Proceedings in case of default.* If the lessee shall not comply with any of the provisions of the Act or the regulations thereunder or default in the performance or observance of any of the provisions of this lease, and such default shall continue for a period of 30 days after service of written notice thereof by the lessor, the lessor may institute appropriate proceedings in a court of competent jurisdiction for the forfeiture and cancellation of this lease as provided in Section 31 of the Act. If the lessee fails to take prompt and necessary steps to prevent loss or damage to the mine, property, or premises, or danger to the employees, the lessor may enter on the premises and take such measures as may be deemed necessary to prevent such loss or damage or to correct the dangerous or unsafe condition of the mine or works thereof, which shall be at the expense of the lessee. However, the lessee shall not be held responsible for delays or casualties occasioned by causes beyond the lessee's control.

Sec. 8. *Heirs and successors in interest.* Each obligation hereunder shall extend to, and be binding upon, and every benefit hereof shall inure to, the heirs, executors, administrators, successors, or assigns of the respective parties hereto.

Sec. 9. *Unlawful interest.* No Member of, or Delegate to, Congress, or Resident Commissioner, after his election or appointment, or either before or after he has qualified and during his continuance in office, and no officer, agent, or employee of the Department of the Interior, except as provided in 43 CFR 7.4(a)(1), shall be admitted to any share or part in this lease or derive any benefit that may arise therefrom; and the provisions of Section 3741 of the Revised Statutes of the United States, as amended (41 U.S.C. Sec. 22), and Sections 431, 432, and 433, Title 18, U.S.C., relating to contracts, enter into and form a part of this lease so far as the same may be applicable.

THE UNITED STATES OF AMERICA

By /s/ Walter C. Ackerman
(Signing Officer)

Walter C. Ackerman
Acting Assistant Manager, Mining
(Title)

August 12, 1965
(Date)

WITNESS TO SIGNATURE OF LESSEE

ATTEST:

A. Lucius Hubbard
A. Lucius Hubbard, Assistant Secretary

AYRSHIRE COLLIERIES CORPORATION

By:
(Signature of Lessee)
Roy E. Dean, Vice President

(Signature of Lessee)

(Signature of Lessee)

(If this lease is executed by a corporation, it must bear the corporate seal)

(c) Royalty. To pay the lessor a royalty of 17½ cents a ton of 2,000 pounds for the first 10 years of the lease and 20 cents a ton for the remainder of the first 20-year period, succeeding the execution of this lease.

Initial

APPENDIX B

Copy of Public Notice of Availability of Mining and Reclamation Plan

March 3, 1849

United States Department of the Interior

GEOLOGICAL SURVEY

Conservation Division
P. O. Box 2550
Billings, Montana 59103

February 8, 1974

TO WHOM IT MAY CONCERN:

Meadowlark Farms, Inc., record holder of Federal Coal Lease Wyoming 0317682, has submitted for approval a mining and reclamation plan embracing all or part of Sections 3, 4, and 5, T. 47 N., R. 71 W., and Sections 26, 27, 28, 29, 32, 33, and 34, T. 48 N., R. 71 W., Campbell County, Wyoming. The coal underlying the area is Federal Government owned.

The mining and reclamation plan is available for review at the office location below. Pertinent comments are solicited from anyone affected by this proposal. Such comments should be filed before March 15, 1974. Response timely filed will be considered before final approval to the plan is given. Responses should be addressed to:

A. F. Czarnowsky
Area Mining Supervisor
U. S. Geological Survey
P. O. Box 2550
Room 217 Post Office Building
Billings, Montana 59103

Office hours Monday through Friday: 7:30 a.m. to 4:00 p.m.

APPENDIX C

Preliminary Dust Survey and Air Quality Standards

	Page
Part 1 - Preliminary Results of Dust Survey at the Belle Ayr South Mine Site Source: Amax Coal Company Continuing Environmental Research Studies	C-2
Part 2 - Air Quality Standards Source: FES 74-55	C-15

AMAX INC.

Environmental Services Group

4704 Harlan Street
Denver, Colorado 80212

803/433-6151
Telex: 45-556

MEMORANDUM

Subject Dust Survey -- Belle Ayr Properties Date September 12, 1974

To S. R. Jewell

From J. H. Johns, Jr.

INTRODUCTION

In addition to the noise level survey which was conducted at the Belle Ayr Project, a survey was also conducted on both properties to establish baseline concentrations of suspended dust and settleable dust. Some of the results, particularly from the last series of suspended dust samples, were inconsistent with early sampling results and should not be considered reliable until they are confirmed with additional sampling. All sampling results are included in this report and the ones which may not be reliable are so identified.

The Air Quality Division of the state of Wyoming monitors for three parameters with which we are concerned. They are suspended dust, settleable dust, and coefficient of haze. No attempt was made to establish a coefficient of haze baseline, since there were no power outlets in the areas where tape samplers could be used.

CONCLUSIONS

1. Although most of the results obtained so far are adequate, one series of suspended dust samples should not be used until their results are confirmed with some additional tests.

2. Some of the settleable dust samples were ruined by the introduction of foreign matter. The remaining samples seem to be adequate however.

3. Concentrations of suspended dust appear to increase after prolonged dry spells. Because of the high ambient suspended dust concentrations that seem to exist during prolonged dry periods, it may be difficult to obtain sample results which will meet state standards during these dry spells.

-- more --

4. Around the Belle Ayr properties, suspended dust comes from two sources. Most of the dust is from traffic travelling along unpaved county roads. The other source of dust is the dump pocket and crusher complex at the Belle Ayr Mine.

5. The concentrations of suspended dust seem to diminish with distance downwind from the source. Even if dust concentrations become temporarily high from time to time, the concentrations should be significantly lower at the property boundary.

6. The dust level at both sites can be suppressed by oiling the county roads in the vicinity of the two AMAX properties. The roads should be oiled at county expense if possible.

7. Most of the dust in the vicinity of the crusher complex is from coal dust collected in the crusher building and exhausted into the atmosphere through the ventilation system. This dust can be suppressed by installing scrubbers at the exhaust fan outlets if it ever becomes necessary.

RECOMMENDATIONS

1. In order to resolve the apparent inconsistency in the results of the survey at the Belle Ayr North, additional suspended dust level samples should be taken at the north site. The samples should be taken after a prolonged dry spell. The last set of samples, which seemed to be inconsistent, exceeded the state standards for suspended dust from industrial operations by a factor of two or more. The confirming samples should be taken prior to any industrial activity.

2. A survey to establish coefficient of haze should be conducted at both sites sometime in the near future. According to Mr. Randolph Wood of the Wyoming Air Quality Division, coal mines in the state of Wyoming have no difficulty meeting the standards of suspended dust and settleable dust, but do have difficulty meeting state standards with respect to coefficient of haze.

DISCUSSION

In conducting the air quality baseline survey, two parameters were monitored. The parameters were suspended dust and settleable dust concentrations. Concentrations of suspended dust were determined using Mine Safety Appliance Co. (MSA) Model G dust pumps which were available at the Belle Ayr Mine (Figure 1 and 2). Settleable dust sampling was conducted using aluminum dust collection jars having a uniform cross section (Figure 3).

-- more --

The Model G dust pumps are small, portable, battery powered air pumps which are normally set to pump at the rate of two liters per minute. If properly adjusted they will pump at a constant rate for eight hours or more. Samples are obtained by placing preweighed filter papers over the intake to the pump and operating the pump in the field for about eight hours. On the day prior to taking the samples, each pump is calibrated with a filter in place, and its pumping rate is determined. During the time the samples are being taken in the field, the exact time at which each pump is started and stopped is recorded. The pump is inspected periodically to insure that its pumping rate does not vary from its calibrated rate. At the end of eight hours or so, the pump is shut off and the filter holder is covered. Later, the entire filter holder unit containing the preweighed filter paper is returned to the laboratory where the filter paper is weighed and the dust concentration is calculated.

By using eight pumps at one time, eight samples at as many locations can be taken simultaneously under the same atmospheric and wind conditions. The results when plotted on a map present a graphic illustration of dust concentration patterns, and identify dust sources and their effect. Samples taken on different days can not be combined since the variation from day to day will be much greater than from place to place. The only valid comparison is between samples taken on the same day under the same weather conditions.

Settleable dust samples were taken using aluminum dust collection jars available from Corning Laboratories, Inc. (Figure 3). Twelve jars were used; six for the north, and six for the south. Each jar was weighed prior to placing in the field. Because of limitations of the scales at the mine, it was not possible to weigh the jars any closer than 0.1 gram. Because of this, the jars were left in place for longer than 30 days, in fact they were left in place for 81 days. When the jars were recovered, several were missing, several had other objects other than dust, e.g. bird droppings, twigs, dead insects, etc. One jar had a raptor pellet stuck to the bottom, and another was found torn from its position and half buried in the ground. Apparently, a cow had torn it off, while using the fence post to which it had been attached, as a scratching post. Of the twelve jars originally put out, only three had reliable results. However, it is believed that these three indicate that settleable dust will not be a serious problem.

A total of 23 suspended dust samples were taken at the Belle Ayr North and South properties between the middle of January and the middle of May, 1974. Eight samples were taken on January 17, 1974 of which four were taken on the north site, and four were taken on the south site. (Table 1 and 2; Figure 4 and 5). The samples were taken by Mr. Stan Thielke,

-- more --

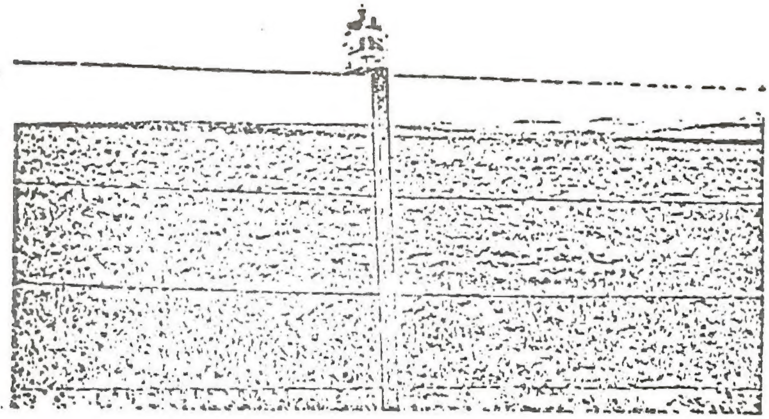


Figure 1. Mine Safety Appliances (MSA) Model G dust pump. These pumps were used to determine suspended dust concentrations.

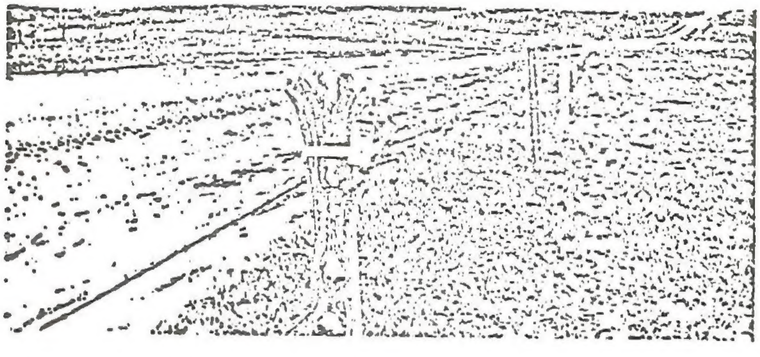


Figure 2. Another view of MSA Model G dust pump.

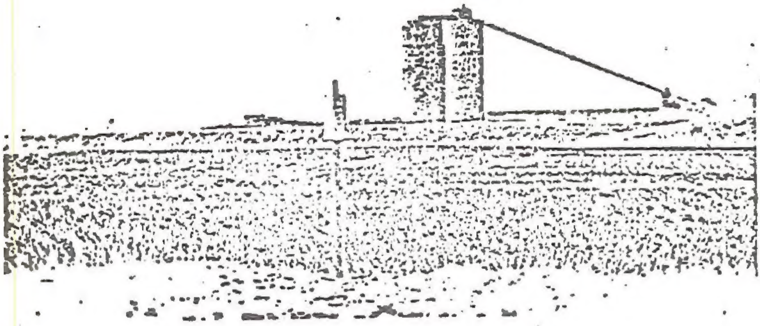


Figure 3. Aluminum dust collection jars of uniform cross section used to collect settleable dust samples.

Table 1.

HENDERSON MINE
CLIMAX MOLYBDENUM COMPANY
Empire, Colorado

INDUSTRIAL HYGIENE SURVEY DATA

Date: January 17, 1974

Location: Belle Ayr Mine, AMAX, Gillette, Wyoming

Purpose: Particulate Concentration Determinations

Equipment: MSA portable pumps, Model G; Gelman Metrical, GA-4 filters, 25 mm. diameter, 0.8 micron pore size

Calibration: On site, 2 liters per minute

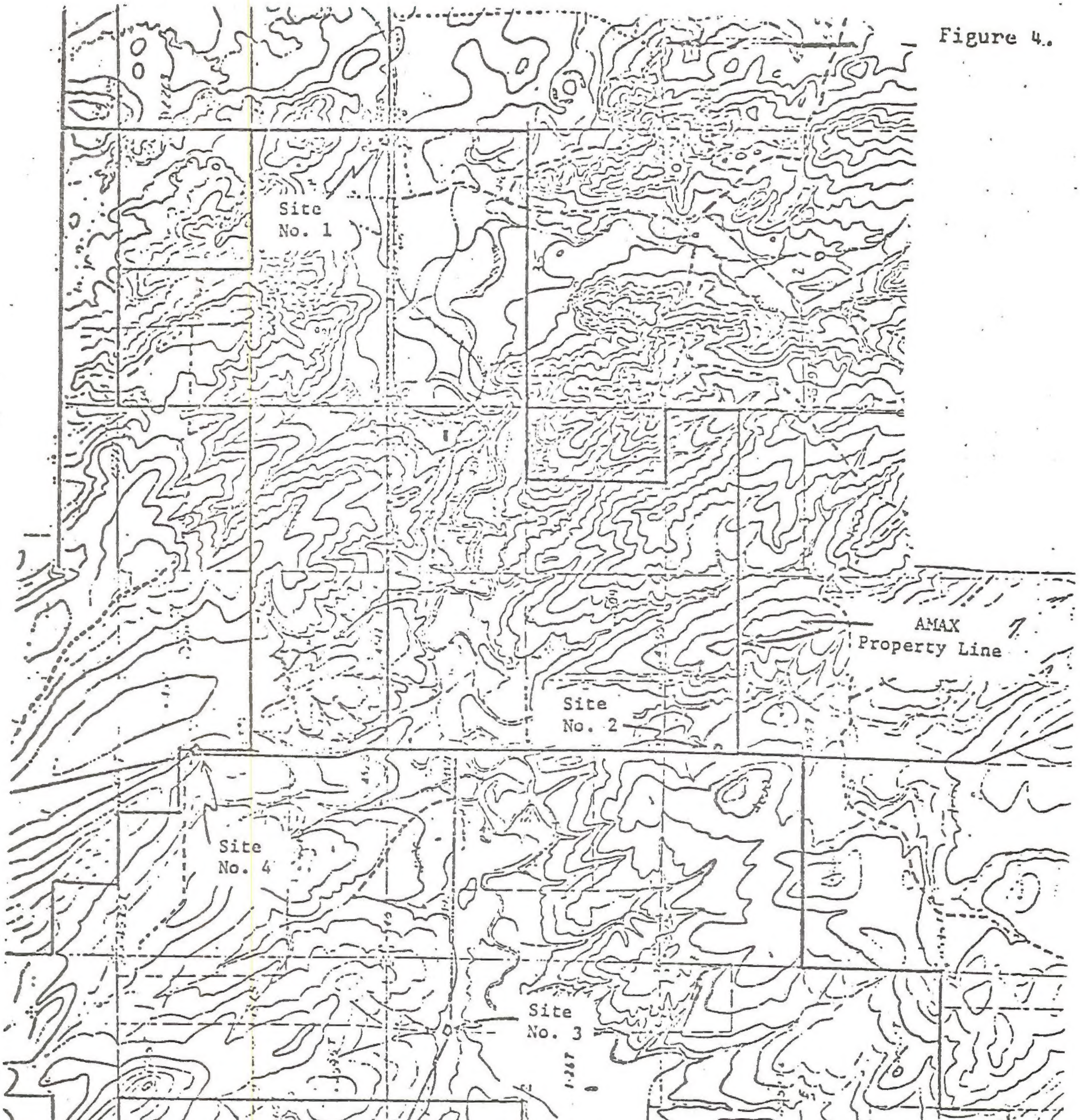
Weather Conditions: Partly cloudy. 15 to 20 mile per hour winds out of the west.

Site No.[1]	Sample Data				Filter Data			Particulate Concentration Micrograms/ Cubic Meter	Comments
	Pump No.	Time On	Time Off	Volume Sampled (liters)	No.	Weight (Milligrams) Tare (T)	Weight (Milligrams) Sample +T		
1	1	6:01 AM	2:30 PM	1018	3	17.182	17.226	43	Sample taken adjacent to a dirt Light vehicle traffic. Site is located East of the Belle Ayr Mi
2	2	6:16 AM	2:42 PM	1012	4	15.749	15.851	101	Sample taken East of dirt road. Moderate traffic.
3	3	6:25 AM	2:46 PM	1002	5	15.781	15.808	27	Sample taken adjacent to dirt ro Light Traffic.
4	4	6:35 AM	2:37 PM	964	6	16.041	16.102	63	Sample taken East of dirt road. Moderate traffic.

---

[1] See attachment No. 5 for Site Locations.

Figure 4.


Site
No. 1
AMAX
Property Line
Site
No. 2
Site
No. 4
Site
No. 3

AMAX
Belle Ayr Mine Property
Gillette, Wyoming
Environmental Sampling Site

Industrial Hygienist at the Henderson Project. On March 29, 1974, seven dust samples were taken on the Belle Ayr South property exclusively (Table 3; Figure 6), and on May 15, 1974, eight samples were taken on the Belle Ayr North property exclusively (Table 4; Figure 7).

The results of the sampling indicate that the major sources of dust are the county roads which are unpaved (Figure 8, 9 and 10) and the area around the dump pocket and crusher building (Figure 11). The dust concentrations increase abruptly on the downwind side of the county roads and then gradually diminish with distance until another source of dust is encountered. The dust in the area of the dump pocket is fugitive dust generated when a truck dumps a load of coal, and does not come from traffic on the haul road. This dust is caused only during the dumping operation which is for 10 to 15 seconds every two or three minutes or so. It does not occur when the trucks are not hauling coal. Very little dust is caused by traffic on the haul roads, no doubt because of the dust suppression measures used (Figure 12). The dust from the crusher is the exhaust from the ventilation system and is continuous, rather than intermittent, as long as the crushers are operating. This dust could be easily controlled with the installation of scrubbers if it ever becomes necessary. Present data indicate it probably will not be necessary until full production is attained.

The results of sampling on the north site show a much higher concentration of dust than in the south despite the lack of industrial activity in the north. These samples were taken on a day which had followed a long dry spell. Mr. Thielke has stated that any errors in the adjustment of the Model G dust pump generally result in extremely high readings. However, all of the results were high and it would seem that if there were adjustment errors only one or two of the results would have been high. In any event, the results of the sampling on May 15, 1974 should not be considered final or even acceptable until confirmed under similar atmospheric conditions. It should also be pointed out that the sampling on March 29, 1974 was on a fairly chilly day and that there had been some rain on the previous day.

The results of the settleable dust samples indicate that both properties meet Wyoming air quality standards. There were not enough satisfactory results to conclude any more than that. (Table 5, Figure 13).

No coefficient of haze samples were taken at either site. Coefficient of haze determinations would require the use of a tape sampler and 110 volt current. Power was not available on the north site and was available on the south site only in the vicinity of the mine office. Mr. Randolph Wood of the Wyoming Air Quality Division stated that coal mines in Wyoming have little or no trouble meeting state standards with respect to

-- more --

Table 3.

HENDERSON MINE
CLIMAX MOLYBDENUM COMPANY
Empire, Colorado

INDUSTRIAL HYGIENE SURVEY DATA

Date: March 29, 1974

Location: AMAX Property, Gillette, Wyoming

Purpose: Particulate Concentration Determinations

Equipment: MSA Portable pumps, Model G; Gelman Metricel, GA-4 filters, 25 mm. diameter, 0.8 micron pore size.

Calibration: On site, as indicated below.

Weather Conditions: Clear, moderate winds from the West-Northwest.

Sample Data					Filter Data				
Pump No.	Time On	Time Off	Flow Rate (LPM)	Volume sampled (liters)	Holder No.	Filter No.	Weight (milligrams) Tare (T)	Weight (milligrams) Sample +T	Particulate Concentrati Micrograms/Cubic Meter
1	7:41 AM	3:24 PM	1.98	916.74	1	1	15.825	15.861	39.27
3	7:31 AM	3:15 PM	1.37	635.68	2	2	15.732	15.680	81.80
5	7:21 AM	3:10 PM	1.98	928.62	3	3	15.775	15.749	28.00
6	7:13 AM	3:03 PM	1.82	855.40	6	4	17.280	17.263	19.87
7	7:07 AM	2:58 PM	2.01	946.71	7	5	16.860	16.853	7.39
8	6:57 AM	2:51 PM	1.29	611.46	8	7	16.849	16.828	34.34
9	6:44 AM	2:45 PM	1.95	937.95	11	9	17.225	17.210	15.99

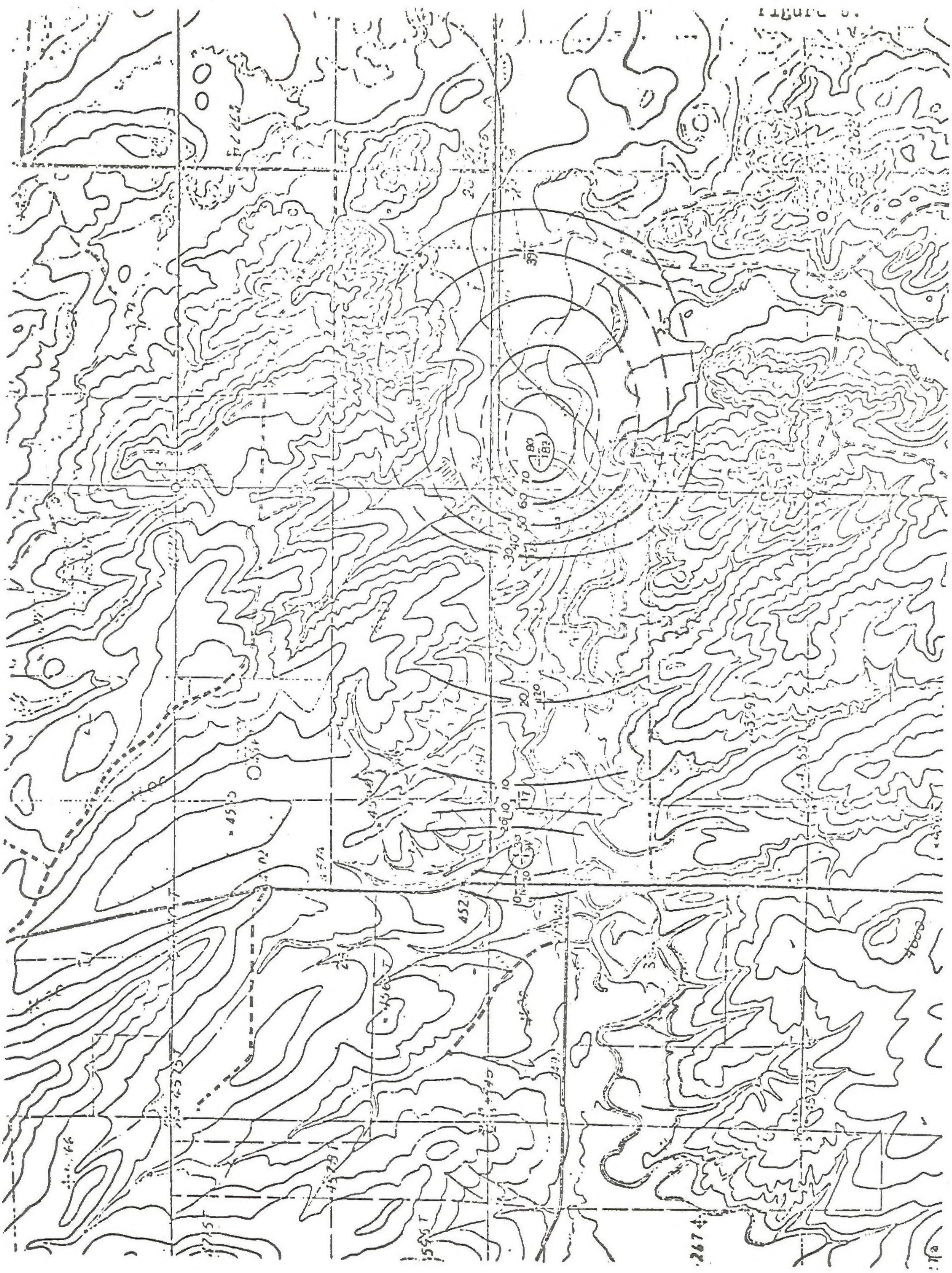


Figure 6.

39
30
40
50
60
70
80
183
20
120
10
17
452
4000

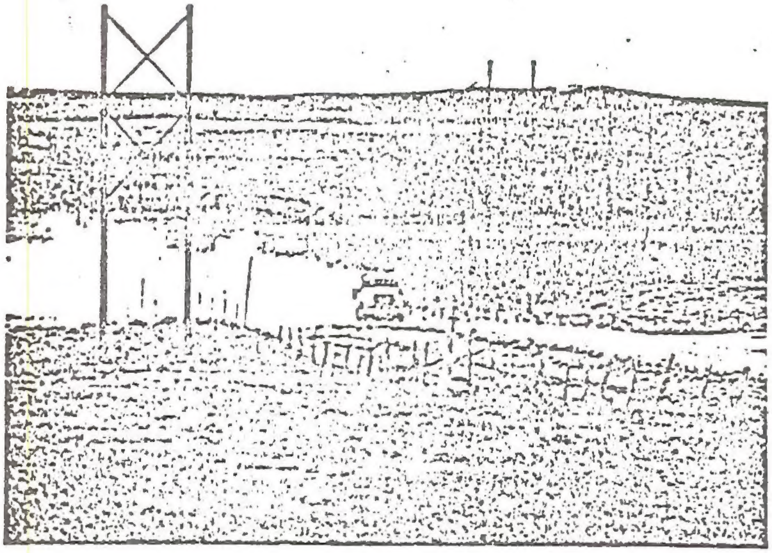


Figure 8. Dust caused by traffic travelling on unpaved county roads.

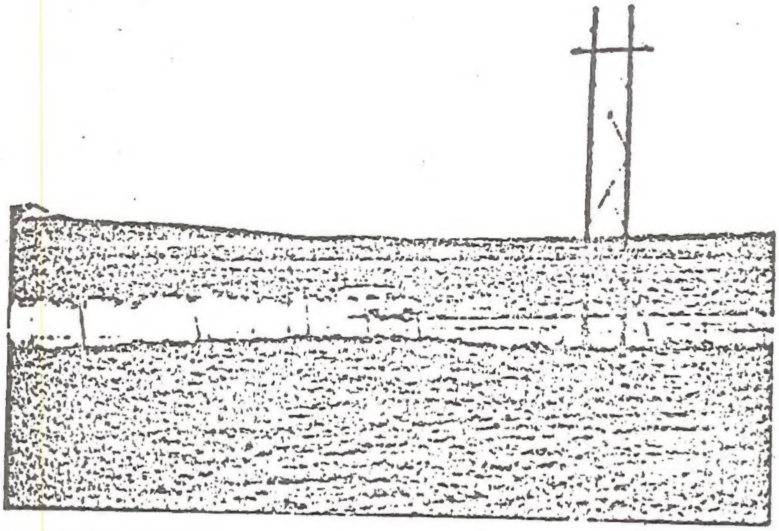


Figure 9. Traffic dust on county road T-7 about 1½ miles west of Belle Ayr Mine.

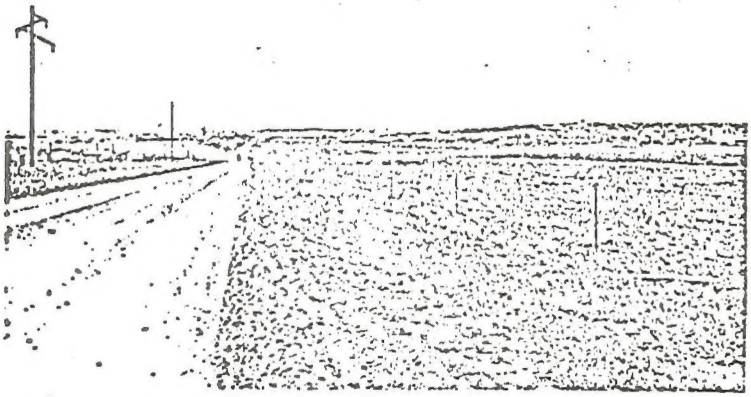


Figure 10. Traffic dust on county road which runs north and south and is on eastern edge of Belle Ayr North site.

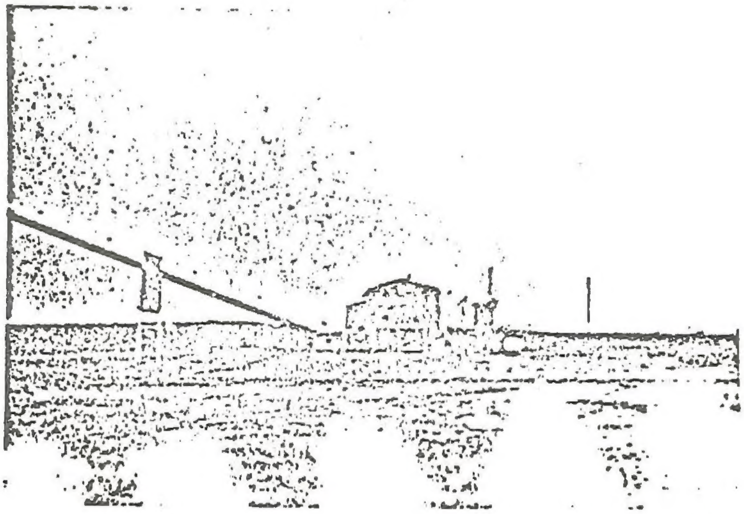


Figure 11. Dust from dump pocket-crusher complex at Belle Ayr Mine. Plume of dust to left of building and above conveyor gallery is from crusher exhaust system. The rest is from the truck dumping.

settleable dust or suspended dust but do have difficulty at times meeting state standards with respect to coefficient of haze. An attempt was made to have the University of Wyoming conduct a coefficient of haze survey but they were unable to obtain the use of tape samplers. This approach was abandoned for the time being. Perhaps an attempt can be made in the future.

Jim
J. H. Johns, Jr.

JHJ/kcd
Attach

Air Quality

The enforcement of all applicable federal and state laws and regulations concerning air quality standards for control of emissions will reduce the cumulative effects on air quality of regional development. These include:

1. Federal Clean Air Act, as amended in 1970;
2. National Ambient Air Quality Standards;
3. New Source Performance Standards (NSPS);
4. National Emission Standards for Hazardous Air Pollutants;
5. Wyoming Environmental Quality Act of 1973; and
6. Wyoming Ambient Air Quality Regulations.

Development and utilization of reliable emission control equipment on existing and new equipment, vehicles and plant stacks will reduce the cumulative amount of pollutants entering the regional atmosphere.

Air quality standards

National Ambient Air Quality Standards (NAAQS) for suspended particulate matter, sulfur oxides, nitrogen oxides, photochemical oxidants, carbon monoxide, and hydrocarbons were promulgated by the Environmental Protection Agency (EPA) on April 30, 1971, under provisions of the Clean Air Act, as amended in 1970. Table 1 lists these standards. It is the responsibility of the Wyoming Department of Environmental Quality to insure that these standards are attained and maintained. If the state does not carry out this responsibility, EPA must take action to enforce the standards. Primary standards are health related and, in most cases, must be achieved by July 1975. Secondary standards are welfare related (material, vegetation, visibility, etc.) and must be achieved as expeditiously as possible. In rural areas this may mean July 1975, whereas in urban areas it may mean well beyond July 1977.

Wyoming ambient air quality standards were promulgated in accordance with the Wyoming Environmental Quality Act of 1973. Under Article 2 of the Act the Wyoming Department of Environmental Quality, Air Quality Division, is empowered to enforce standards. Table 2 contains the Wyoming ambient air quality standards. Wyoming has also adopted emission regulations; these standards are shown in Table 3.

Any new fossil fuel-fired steam generators or modification to existing plants must conform to the New Source Performance Standards (NSPS). Table 4 lists these standards.

Table 1

National Ambient Air Quality Standards

Pollutant	Primary Standard	Secondary Standard
1. Sulfur Oxides	80 ug/m^3 (0.03 ppm) annual arith. mean 365 ug/m^3 (0.14 ppm) max. 24 hr. conc. not to be exceeded more than once a year.	1300 ug/m^3 (0.5 ppm) max. 3 hr. conc. not to be exceeded more than once a year.
2. Particulate Matter	75 ug/m^3 annual geom. mean 260 ug/m^3 max. 24 hr. conc. not to be exceeded more than once a year.	60 ug/m^3 annual geom. mean*, 150 ug/m^3 max. 24 hr. conc. not to be exceeded more than once a year.
3. Carbon Monoxide	10,000 ug/m^3 (9 ppm) max. 8 hr. conc. not to be exceeded more than once a year.	Same as primary.
	40,000 ug/m^3 (35 ppm) max. 1 hr. conc. not to be exceeded more than once a year.	Same as primary.
4. Photo Chemical Oxidants (corrected for NO_2 and SO_2 interference.	160 ug/m^3 (0.08 ppm) max. 1 hr. conc. not to be exceeded more than once a year.	Same as primary.
5. Hydrocarbons (corrected for CH_4)	160 ug/m^3 (0.24 ppm) max. 3 hr. conc. (6 to 9 a.m.) not to be exceeded more than once a year.	Same as primary.
6. Nitrogen Oxides (as Nitrogen Dioxide)	100 ug/m^3 (0.05 ppm) annual arith. mean.	Same as primary.

*To be used as guide in assessing State Implementation Plans.

Table 2

Wyoming Ambient Air Quality Standards

Pollutant	Standard						
	Annual	Month	24-hour	8-hour	3-hour	1-hour	1/2 hour
Particulate, ug/m^3	60 G.M.	-	150**	-	-	-	-
, COH/1000 feet	0.4	-	-	-	-	-	-
SO_2, ug/m^3	60	-	260**	-	1.300**	-	-
, sulfation mg SO_3/100 cm^2/day	0.25	0.50	-	-	-	-	-
CO, mg/m^3	-	-	-	10**	-	40**	-
NO_x, ug/m^3	100 A.M.	-	-	-	-	-	-
HC, ug/m^3	-	-	-	-	160**	-	-
Oxidants, ug/m^3	-	-	-	-	-	160**	-
HF, total, ppb	-	-	1	-	-	-	-
HF, forage - ppmw	25	-	-	-	-	-	-
HF, gaseous - ug/cm^2	-	0.3	-	-	-	-	-
H_2S, ug/m^3	-	-	-	-	-	-	40*twice/ 5 days 70*twice/ year

*Not to be exceeded more than

**Not to be exceeded more than once per year

Table 3

Wyoming Emission Standards

A. Fuel Combustion - Particulate Matter

10^6 Btu/hr. Fuel Heat Input*	# Particulate/10^6 Btu Existing Source	# Particulate/10^6 Btu New Source**
10	0.6	0.10
10,000	0.18	0.10

B. Fuel Combustion - NO_x

Fuel Fired	# NO_x/10^6 Btu Existing Source	# NO_x/10^6 Btu New Source**
Gas	0.23	0.2
Oil	0.46	0.3

C. Visible Emissions

Existing Source	40 percent opacity
New Source**	20 percent opacity

*Interpolate between values
**After February 22, 1972

Table 4

NSPS for Steam Generators

	Allowable Emissions Fuel-Fired Coal	Oil	Gas
Particulate, #/10^6 Btu	0.10	0.10	0.10
Particulate, opacity	20%	20%	20%
Sulfur dioxide, #/10^6 Btu	1.20	0.80	--
Nitrogen oxides, #/10^6 Btu	0.70	0.30	0.20

APPENDIX D

Summary Data From
Meterological Station
at the
Belle Ayr South Mine Site

Source: Amax Coal Company Continuing
Environmental Research Studies

Microclimate

At the request of WRRI, AMAX installed a weather station at both its South and North mine sites (figures 1-1 and 1-2). The stations are instrumented with a Belfort weighing-recording precipitation gage, an Epic hygrothermograph in a cotton-region shelter, an Epic recording anemometer, and a Belfort microbarograph. The precipitation gages are protected from adverse wind effects by a Wyoming Shield (Rechard, et al. 1973). In addition, at the South site the U.S. Forest Service has installed a similar precipitation gage with an Alter-type wind shield, while at the North site WRRI has installed a similar precipitation gage with no wind shield.

There was some delay in obtaining the new instruments installed by AMAX after this investigation was initiated, and the installation of these instruments was not completed until March. The data for the two sites are given in Tables 2-14 through 2-18.

TABLE 2-14

MICROCLIMATOLOGICAL DATA
AMAX SOUTH

	Temperature (°F)			Relative Humidity (%)			Atmos. Press. (in Hg)	
Date	Max	Min	Mean	Max	Min	Mean	Max	Min
2-14-74					36	65		
15	38	20	29	99	40	77		
16				99	30	44		
17				56	99	88		
18	38	18	28	99	39	67		
19	43	20	31	90	37	74		
20	37	14	25	97	76	87		
21	32	10	21	97	37	62		
22	39	19	29	99	29	65		
23	22	08	15	99	87	95	30.41	29.98
24	27	08	17	97	59	80	30.42	30.28
25	43	10	26	96	45	50	30.26	29.96
26	50	26	38	85	29	39	29.96	29.70
27	38	18	28	90	30	65	30.08	29.69
28	53	17	35	99	31	45	30.08	29.76
3-1-74	57	40	48	60	34	45	29.80	29.58
2	60	18	39	99	37	68	29.58	29.34
3	37	16	26	99	40	75	29.72	29.58
4	37	15	26	28	29	42	29.77	29.70
5	46	30	38	57	36	46	29.71	29.53
6	39	25	32	99	55	89	29.78	29.53
7	43	25	34	99	54	79	29.75	29.65
8	55	18	36	99	25	61	30.18	29.71
9	44	16	30	99	26	44	30.29	30.19
10	41	22	31	99	53	72	30.23	29.96
11	50	20	35	99	30	57	30.13	29.95
12	54	20	37	99	29	44	30.16	29.94
13	59	19	39	99	26	67	30.02	29.76
14	40	20	30	98	21	49	30.10	29.94
15	34	19	26	85	36	62	30.24	30.10
16	52	28	40	95	37	51	30.20	30.03
17	61	28	44	99	26	63	30.01	29.86
18	32	23	27	99	63	91	30.13	29.90
19	26	09	17	99	85	92	30.17	30.87
20	19	01	10	91	50	75	30.20	29.98
21	32	05	18	99	48	83	29.97	29.76
22	10	-01	04	90	72	86	30.06	29.96
23	13	00	04	86	65	78	30.11	29.98
24	33	05	19	99	55	76	29.96	29.90
25	42	17	29	99	36	73	29.99	29.92
26	49	22	35	98	42	61	30.05	29.98
27	58	32	45	85	29	58	29.99	29.82
28	57	32	44	99	31	62	29.90	29.64
29	48	23	35	99	28	70	30.60	29.90
30	56	22	39	99	31	70	29.99	29.55
31	41	25	33	99	46	68	29.78	29.59

TABLE 2-14 (cont.)

MICROCLIMATOLOGICAL DATA
AMAX SOUTH

Date	Temperature (°F)			Relative Humidity (%)			Atmos. Press. (in Hg)	
	Max	Min	Mean	Max	Min	Mean	Max	Min
4-1-74	50	20	35	99	22	56	29.77	29.48
2	42	26	34	99	47	81	29.83	29.48
3	32	26	29	98	62	87	30.11	29.84
4	36	21	28	99	62	87	30.26	30.11
5	51	18	34	99	24	49	30.23	29.88
6	54	35	44	92	33	59	29.97	29.76
7	38	27	32	99	60	77	30.23	29.97
8	52	20	36	65	20	39	30.21	30.02
9	60	29	44	90	26	46	30.00	29.55
10	50	29	39			79	29.78	29.54
11	29	26	27				29.85	29.73
12	33	26	29				30.00	28.71
13							30.30	30.01
14							30.30	30.20
15							30.21	30.16
16							30.16	29.98
17							30.14	30.02
18					23	97	30.01	29.84
19	60	40	50	97	30	65	29.82	29.68
20	40	35	37	97	90	94	29.87	29.66
21	42	27	34	99	41	80	30.16	29.80
22	56	25	40	99	27	46	30.18	30.01
23	60	37	48	90	35	58	30.14	29.98
24	71	39	50	95	17	37	30.08	29.98
25	69	50	59	86	26	42	30.13	30.00
26	65	40	52	99	25	83	29.99	29.79
27	52	24	38	99	20	60	30.02	29.88
28	45	22	33	99	46	76	30.26	30.20
29	51	29	40	97	33	58	30.33	30.26
30	62	28	45	99	22	52	30.30	30.04
5-1-74	69	30	49	98	20	48	30.03	29.72
2	42	26	34	99	40	80	30.20	29.76
3	52	25	38	97	23	55	30.19	30.09
4	57	24	40	98	24	49	30.22	30.14
5	64	26	45	97	23	47	30.22	30.03
6	71	32	51	95	19	51	30.06	29.86
7	60	39	49	93	38	56	30.01	29.94
8	65	34	49	99	38	68	29.97	29.81
9	68	32	50	99	22	54	29.96	29.69
10	44	28	35	49	45	77	29.93	29.79
11	51	24	37	99	22	42	30.02	29.92
12	65	24	44	88	24	42	30.02	29.53
13	49	27	38	97	27	74	29.86	29.48
14	44	24	34	97	39	53	29.88	29.78
15	52	29	40	90	50	50	29.86	29.64
16	57	28	42	90	21	46	30.04	29.86
17	33	44	38	99	36	86	30.04	29.90

TABLE 2-14 (cont.)

MICROCLIMATOLOGICAL DATA
AMAX SOUTH

	Temperature (°F)			Relative Humidity (%)			Atmos. Press.(in Hg)	
Date	Max	Min	Mean	Max	Min	Mean	Max	Min
5-18-74	64	41	52	97	51	81	29.96	29.85
19	53	43	48	99	93	99	29.93	29.71
20	50	34	42	99	45	81	30.00	29.76
21	50	29	40	99	27	62	30.12	29.98
22	54	32	43	95	30	59	30.16	30.11
23	61	28	45	99	27	59	30.15	30.09
24	69	40	54	75	24	49	30.17	30.11
25	61	45	53	98	48	73	30.23	30.18
26	72	44	58	99	25	52	30.17	29.96
27	71	47	59	97	32	68	30.02	29.85
28	62	40	51	99	52	85	30.16	29.94
29	47	41	44	99	80	92	30.08	29.84
30	43	36	39	99	62	84	30.18	29.91
31	57	27	42	99	27	71	30.24	30.06
6-1-74	62	29	45	99	24	51	30.25	30.10
2	73	36	54	97	17	27	30.01	29.98
3							29.98	29.91
4							29.91	29.82
5							29.96	29.78
6							29.96	29.78
7							29.89	26.68
8							30.06	29.90
9							30.15	30.05
10							30.30	30.15
11							30.31	30.14
12							30.13	30.04
13							30.18	29.99
14	76	40	58	94	25	53	30.27	30.17
15	74	40	57	92	24	38	30.29	30.16
16	73	49	61	74	35	52	30.14	29.98
17	83	50	66	80	23	42	29.98	29.86
18	89	51	70	75	20	34	29.99	29.88
19	90	52	71	95	16	40	30.01	29.94
20	93	55	74	89	15	33	29.96	29.81
21	71	54	62	97	40	69	29.86	30.13
22	74	46	60	97	36	57	30.16	30.09
23	80	56	68	97	33	61	30.18	30.10
24	88	50	69	97	21	51	30.16	30.04
25	92	52	72	91	15	40	30.06	29.93
26	94	61	77	60	15	39	30.04	29.88
27	88	52	70	65	19	39	30.07	29.96
28	82	52	67	64	26	43	30.09	29.96
29	76	53	64	61	33	44	30.21	30.06
30	85	48	66	70	22	66	30.17	29.87

TABLE 2-16

PRECIPITATION DATA
SOUTH SITE

Day	Feb	Mar	Apr	May	June
1		.00	.10	.00	.00
2		.00	.14	.05	.00
3		.10	.13	.00	.00
4		.00	.00	.00	.00
5		.00	.03	.00	.05
6		.00	.00	.00	.00
7		.00	.00	.00	.22
8		.00	.00	.00	.01
9		.00	.05	.00	.00
10		.00	.12	.00	.00
11		.00	.10	.00	.00
12		.00	.07	.00	.00
13		.00	.00	.00	.00
14		.00	.01	.00	.00
15	.00	.00	.00	.00	.00
16	.00	.00	.02	.00	.00
17	.00	.04	.00	.40	.00
18	.00	.02	.00	.00	.00
19	.00	.20	.00	.03	.00
20	.00	.00	.54	.12	.00
21	.00	.00	.02	.00	.00
22	.00	.00	.00	.03	.00
23	.00	.07	.00	.00	.18
24	.00	.00	.00	.00	.00
25	.13	.00	.00	.15	.00
26	.00	.00	.13	.09	.00
27	.00	.00	.04	.05	.00
28	.00	.00	.00	.15	.00
29		.00	.05	.28	.00
30		.13	.05	.00	.00
31		.12		.00	
Total	.13	.68	1.60	1.35	.46

TABLE 2-19
WIND DATA, BELLE AYR NORTH AND SOUTH MINE SITES

	AMAX NORTH				AMAX SOUTH			
Date	Average Daily Wind Speed (mph)	Average Daily Wind Dir.	Max. Hourly Wind Speed (mph)	Wind Dir. At Max. Wind Speed	Average Daily Wind Speed (mph)	Average Daily Wind Dir.	Max. Hourly Wind Speed (mph)	Wind Dir. At Max. Wind Speed
3-29-74	10*	V	25	NW	6*	W	7	NW
30	7	SW	16	SW	8	W	19	SW
31	9	V	22	NW	7	W	19	NW
4-1-74	6	W	14	NW	9	SW	17	W
2	10	N	19	N	11	V	22	N
3	10	N	15	N	10	N	14	N
4	6	V	13	N	6	NW	15	N
5	6	SW	12	SW	4	V	11	S
6	11	NW	20	NW	11	NW	19	N
7	15	NW	24	NW	12	NW	19	NW
8	6	V	11	W	2	V	7	SW
9	15	S	27	SE	10	SE	19	SE
10	13	NE	24	NE	11	V	20	NE
11	18	N	24	N	17	N	22	N
12	7	N	14	N	7	N	12	N
13	17	N	23	N	16	N	24	N
14	11	NW	24	N	11	NW	20	NW
15	7	V	19	S	7	V	17	S
16	8	V	20	S	5	V	9	V
17	5	V	12	N	4	NW	9	N
18	14	S	24	S	11	S	15	SE
19	12	V	16	N	21	V	14	N
20	13	N	19	N	15	N	22	N
21	15	NW	25	NW	13	NW	22	NW
22	5	SW	10	W	4	V	10	S
23	17	S	24	SE	11	SE	18	SE
24	8	S	17	S	4	SE	15	S
25	13	S	22	S	10*	SE	16	S
26	11	V	20	W	14*	V	24	SW
27	6	NW	21	NW	9	NW	23	SW
28	9	N	17	NW	7	N	14	N

TABLE 2-19 (cont.)

	AMAX NORTH				AMAX SOUTH			
Date	Average Daily Wind Speed (mph)	Average Daily Wind Dir.	Max. Hourly Wind Speed (mph)	Wind Dir. At Max. Wind Speed	Average Daily Wind Speed (mph)	Average Daily Wind Dir.	Max. Hourly Wind Speed (mph)	Wind Dir. At Max. Wind Speed
4-29-74	9	NW	16	NW	7	NW	13	N
30	4	SW	10	SW	4	SW	11	SW
5-1-74	7	SW	16	W	7	SW	19	W
2	12	N	20	N	15	N	17	NW
3	8	S	17	S	5	S	14	S
4	8	V	16	N	6	NW	18	N
5	4	V	9	S	3	V	7	SW
6	6	V	16	N	5	V	16	N
7	9	NW	14	NW	7	W	13	NW
8	7	V	21	N	5	V	24	N
9	8	V	16	S	6	V	14	N
10	9	NW	16	N	9	N	15	N
11	14	V	26	NW	11	NW	20	NW
12	14	S	27.	S	9	S	17	S
13	21	NW	37	NW	19	NW	30	NW
14	no data		no data		8	V	17	NW
15	9	N	15	N	11	V	20	W
16	6	V	13	NE	7	V	16	NE
17	11	V	20	SE	11	V	18	SE
18	18	SE	31	SE	15	SE	22	SE
19	11	NW	16	NW	10	N	20	N
20	12	NW	15	NW	11	NW	15	W
21	12	NW	18	NW	11	W	24	W
22	12	NW	22	NW	9	NW	19	NW
23	4	V	7	N	4	V	8	NE
24	6	V	12	S	4	V	11	S
25	4	NE	7	NE	6	NE	11	NE
26	4	V	11	W	4	V	9	W
27	9	V	23	NW	5	V	19	N
28	7	V	23	N	9	V	25	N
29	8	SE	21	S	5	SE	9	S

TABLE 2-19 (cont.)

	AMAX NORTH				AMAX SOUTH			
Date	Average Daily Wind Speed (mph)	Average Daily Wind Dir.	Max. Hourly Wind Speed (mph)	Wind Dir. At Max. Wind Speed	Average Daily Wind Speed (mph)	Average Daily Wind Dir.	Max. Hourly Wind Speed (mph)	Wind Dir. At Max. Wind Speed
5-30-74	11	N	23	NW	11	N	24	NW
31	7	V	22	N	7	V	33	N
6-1-74	4	V	9	SW	4	V	7	V
2	3	V	6	N	4	V	10	SW
3	4	V	9	NW	5	V	12	N
4	11	V	24	SW	12	V	24	W
5	7	V	27	NW	7	NW	19	N
6	6	NW	15	NW	5	NW	12	NW
7	8	N	17	NW	7	V	22	W
8	7	N	11	NW	8	N	14	N
9	8	N	17	N	7	NW	14	N
10	5	V	20	N	no data		no data	
11	3	V	7	N	no data		no data	
12	6	V	12	N	no data		no data	
13	8	V	12	N	6	V	14	N
14	6	NE	11	NE	4	V	15	N
15	6	V	15	E	6	V	14	E
16	12	S	22	S	9	SE	15	S
17	6	V	11	S	6	V	11	N
18	4	V	13	NW	6	V	20	SW
19	5	V	9	SW	6	V	15	W
20	11	SW	19	W	11	SW	23	W
21	11	N	29	N	9	N	15	NW
22	4	V	12	SE	4	V	10	SE
23	15	S	20	SE	13	SE	9	SE
24	10	S	19	S	6	SE	16	S
25	8	SE	20	SE	6	SE	14	SE
26	12	V	20	N	10	V	22	N
27	5	V	12	N	6	V	12	NE
28	6	N	18	N	8	V	20	NW
29	5	N	11	N	6	N	14	N
30	7	V	9	SW	3	V	7	NW

APPENDIX E

Overburden Trace Element Analysis Data

	Page
Part 1 - Trace Element Content of Coal and Overburden	E-2
Source: FES 74-55	
Part 2 - Selected Portions of the Evaluation of Overburden Within the Belle Ayr Mine Property of Amax Coal Company, Gillette, Wyoming, by V.P. Wiram	E-13
Source: Amax Coal Company Continuing Environmental Research Studies	

Trace element content of coal and overburden

Investigations of minor and trace elements in coal have been ongoing since coming into prominence in the early 1930's. Zubovic and others (USGS 1961, p. A4-A5) have listed publications of work in 18 countries and the U.S.A. through 1956; O'Gorman and Walker (Office of Coal Research, 1972) have summarized information on trace elements in selected U.S. coals. Swanson (USGS Open File Report, 1972), in addition to giving results of analyses for trace elements for coals to be used for power generation in the southwestern U.S., has described the coal sampling procedure, sample preparation, analytical methods, and limits of detection used by the U.S. Geological Survey in determining trace element contents of coal. The work of O'Gorman and Walker contains average trace element contents of coal. The work of O'Gorman and Walker contains average trace element contents for subbituminous coal and lignite, as does more recent soon-to-be-released work by Swanson on trace element contents of coal analyzed for the Northern Great Plains Resource Study.

Analyses show that coal in the study area of the impact statement in the Powder River Basin contain about the same, or less, amounts of trace metal elements as shown by analyses of coal beds in other areas of the U.S. and throughout the world. Many of these coal beds, as analyzed in the U.S. and other countries, have been used as a source of fuel and power generation for hundred of years. The scientific literature lacks documentation of high levels of pollution by toxic elements from the burning of these coals, except for contribution of oxides of sulfur to smog during air inversion. The trace element contents of the Powder River Basin coals do not show unusual concentrations when compared to trace element contents of coals that have been used for years. Less trace element research has been done on contents of overburden than has been done on coal; fewer samples have been analyzed and even fewer oxidation and leaching tests have been conducted.

Twenty-four samples, believed to be representative of the sedimentary rocks overlying mineable coalbeds in Campbell County, Eastern Powder River Basin, Wyoming, have been analyzed in detail by the U.S. Geological Survey (Tables 13a-13d). These rocks, which are dominantly siltstone, interbedded with lesser amounts of poorly sorted sandstone and carbonaceous shale, are in the Fort Union and Wasatch Formations of early Tertiary age. The compositions of these rocks are not significantly different in any important environmental aspects from compositions of similar sedimentary rocks in other parts of the United States.

Based on the chemical analyses, silica and alumina comprise three-fourths of these overburden rocks, with potassium, magnesium, calcium, and iron oxides comprising most of the remainder (Table 13b). Organic matter, generally as microscopic disseminated material or less commonly as thin coaly layers or particles visible to the naked eye, makes up from less than one to more than ten percent of the rock samples. The sulfur content is low, generally less than 0.5 percent; only one sample (coaly shale, sample No. D168822) contained more than one percent sulfur, and pyrite was visible in this sample.

The trace elements that are generally of environmental concern are listed in Table 13c. Analyses of the 24 overburden samples show that none of these elements are present in abnormally greater amounts than are present in similar rock types throughout the United States. Some of the apparently higher values for arsenic, copper, and zinc are for samples of carbonaceous sediment, which commonly contains greater amounts of these and other metals than non-carbonaceous rocks. A few samples contain slightly more than average amounts of

Table 13 a

Drill-core Information, and Lithologic Description, Carbon and Sulfur Analysis (in percent) of 24 Samples of Rock Overburden Above Coal Beds to be Mined in the Eastern Powder River Basin, Campbell County, Wyoming.

Sample No.	Depth from surface (ft)	Description of lithology	Total carbon percent	Mineral carbon percent	Organic carbon percent	Total sulfur percent
		PEABODY COAL COMPANY, CORE P8-C[1]				
D168820	20-30	Carbonaceous shale, medium gray	1.81	0.10	1.7	0.18
D168821	40-50	Slightly carbonaceous siltstone, light gray	1.38	1.16	.2	.06
D168822	60-70	Slightly carbonaceous shale to coaly shale, light gray to dark gray	1.85	.49	1.4	1.98
D168823	90-100	Carbonaceous claystone, medium gray	3.38	<.01	3.4	.19
D168824	161.0-165.7	Slightly carbonaceous silty shale, medium gray	1.70	<.01	1.7	.09
		ATLANTIC-RICHFIELD COMPANY, CORE BT-81[2]				
D168825	15.5-30.3	Carbonaceous siltstone and shale, medium gray	5.97	.07	5.9	.16
D168826	39.6-43.6	Slightly carbonaceous siltstone and carbonaceous shale, medium gray	.99	.28	.7	.14
D168827	50.5-61.7	Fine-grained sandstone and siltstone, light gray	2.22	1.70	1.5	.07
D168828	66.2-84.5	Carbonaceous silty claystone and shale, medium gray	2.78	1.15	1.6	.49
D168829	159.5-165.5	Carbonaceous shale, medium to dark gray	2.44	<.01	2.4	.11
		KERR-McGEE CORPORATION, CORE 3C-19[3]				
D168830	12.0-42.5	Ferruginous poorly sorted coarse-grained sandstone	1.92	<.01	1.9	.05
D168831	42.5-64.5	Slightly ferruginous siltstone and claystone, tannish grey	.28	.06	.2	.05
D168832	64.5-73.0	Silty claystone, light gray	.73	.28	.4	.09
D168833	73.0-89.0	Slightly carbonaceous clayey siltstone, light gray	1.85	.89	1.0	.22
D168834	93.0-111.5	Slightly carbonaceous claystone and silty claystone, medium gray	.89	.29	.6	.06
D168835	112.5-119.0	Slightly carbonaceous claystone, medium gray	.97	<.01	1.0	.14
		CARTER OIL COMPANY, CORE 97-C[4]				
D168836	10.0-10.4	Ferruginous fine-grained sandstone and silty sandstone	.93	.60	.3	.78
D168837	36.0-36.4	Ferruginous silty claystone, carbonized rootlets, tannish gray	1.32	.90	.4	.76
D168838	52.0-52.4	Slightly carbonaceous clayey siltstone, greenish gray	1.16	<.87	.3	.09
D168839	69.6-70.0	Mottled very carbonaceous mudstone, medium to dark gray	7.18	.01	7.2	.42
D168840	99.0-99.4	Slightly carbonaceous clayey siltstone, medium gray	2.28	.78	1.5	.23
D168841	122.0-122.4	Carbonaceous silty claystone, medium gray	2.87	.20	2.7	.17
		CARTER OIL COMPANY, CORE 123-C[5]				
D168842	260.0-260.4	Carbonacous silty claystone, medium grey	1.86	<.01	1.9	.23
D168843	269.0-269.4	Fine-grained to silty sandstone, very light grey	.28	.16	.1	.36

[1] SE 1/4 sec. 2, T. 41 N., R. 70 W.; collected by W. L. Rohrer, USGS.
[2] NW 1/4 sec. 34, T. 43 N., R. 70 W.; collected by D. B. Tait, ARCO.
[3] NE 1/4 sec. 15, T. 43 N., R. 70 W.; collected by D. A. Jobin, USGS.
[4] SW 1/4 sec. 10, T. 51 N., R. 72 W.; collected by R. J. Waldrem, Carter Oil Company.
[5] SW 1/4 sec. 10, T. 51 N., R. 72 W. (about 430 ft NE of core-hole 97-C); collected by R. J. Waldrem, Carter Oil Company.

Acknowledgements, samples:

The cooperation of Peabody Coal Company, Atlantic-Richfield Company, Kerr-McGee Corporation, and in providing the sample material is greatly appreciated.

Acknowledgements, chemical analyses:

All analyses were made by the Analytical Laboratories Branch, U.S. Geological Survey, Denver, Colorado 80225. The analysts were: E. J. Fennelly, C. Freeman, J. Gardner, P. Guest, J. C. Hamilton, A. W. Haubert, C. Huffman, Jr., L. Lee, R. MacGregor, V. Merritt, H. T. Millard, D. R. Norton, L. B. Riley, V. E. Shaw, J. A. Thomas, R. E. Van Loenen, J. S. Wahlberg, T. L. Yager. The analytical study was coordinated by V. E. Swanson.

Table 13b

Major Oxide Composition (in percent) of 24 Samples of Rock Overburden Above Coal Beds to be Mined in the Eastern Powder River Basin, Campbell County, Wyoming. See table 13a for further description of samples.

Sample No.	SiO_2	Al_2O_3	Na_2O	K_2O	CaO	MgO	P_2O_5	MnO	TiO_2	Fe_2O_3	Cl
PEABODY COAL COMPANY, CORE P8-C											
D168820	65.	17.	0.18	2.0	0.49	1.04	<0.10	0.02	0.75	3.1	<0.10
D168821	66.	13.	.13	1.8	.33	.76	< .10	.09	.63	9.0	< .10
D168822	63.	14.	.16	1.9	.48	.92	< .10	.04	.63	7.8	< .10
D168823	69.	15.	.12	1.6	.29	.61	< .10	<.02	.64	1.5	< .10
D168824	69.	17.	.11	1.9	.17	.59	< .10	<.02	.78	1.3	< .10
ATLANTIC-RICHFIELD COMPANY, CORE BT-81											
D168825	60.	17.	.11	1.8	.50	.84	<.10	<.02	.65	2.6	<.10
D168826	69.	16.	.13	2.0	.37	.80	<.10	.04	.71	3.7	<.10
D168827	67.	11.	.10	1.6	4.0	.85	<.10	.07	.59	6.3	<.10
D168828	56.	18.	.12	1.7	.63	1.20	<.10	.07	.69	9.4	<.10
D168829	63.	21.	.11	1.8	.27	.73	<.10	<.02	.77	1.6	<.10
KERR-McGEE CORPORATION CORE 3C-15											
D168830	78.	8.2	1.08	2.9	.34	.37	<.10	<.02	.23	1.5	<.10
D168831	64.	17.	.13	1.9	.66	.98	.15	.10	.72	6.8	<.10
D168832	68.	15.	.12	2.0	.72	.94	.27	.03	.71	3.7	<.10
D168833	72.	11.	.10	1.6	<.02	.67	.23	.06	.53	4.5	<.10
D168834	64.	19.	.13	1.9	.45	.90	<.10	<.02	.76	3.8	<.10
D168835	62.	23.	.15	1.8	.37	.84	<.10	<.02	.79	2.0	<.10
CARTER OIL COMPANY, CORE 97-C											
D168836	73.	9.5	.35	2.2	3.5	1.43	.17	.02	.42	2.8	<.10
D168837	64.	12.	.13	2.3	3.4	1.98	.11	.04	.59	5.1	<.10
D168838	75.	9.7	.12	2.2	2.8	1.58	.20	.03	.54	2.2	<.10
D168839	55.	16.	.18	2.5	.79	1.23	<.10	<.02	.60	3.1	<.10
D168840	66.	13.	.12	2.3	2.9	1.60	<.10	.03	.63	2.3	<.10
D168841	63.	17.	.13	2.6	1.0	1.33	<.10	.02	.69	2.6	<.10
CARTER OIL COMPANY, CORE 123-C											
D168842	61.	22.	.12	1.6	.36	.84	<.10	<.02	.87	2.2	<.10
D168843	90.	6.8	.07	1.3	.16	.33	<.10	<.02	.31	1.8	<.10

Table 13c

Quantitative Determinations (in parts per million) for 12 Trace Elements in 24 Samples of Rock Overburden Above Coal Beds to be Mined in the Eastern Powder River Basin, Campbell County, Wyoming. See Table 13a for further description of samples.

Sample No.	As	Cd	Cu	F	Hg	Li	Pb	Sb	Se	Th	U	Zn
PEABODY COAL COMPANY, CORE P8-C												
D168820	5	<1	29	790	0.10	35	<25	1.9	<0.1	13.5	4.3	104
D168821	4	<1	20	490	.04	25	<25	---	< .1	10.3	3.8	84
D168822	70	<1	24	620	.11	25	<25	---	< .1	13.2	4.2	70
D168823	4	<1	25	470	.07	26	<25	---	< .1	11.7	4.3	178
D168824	8	<1	20	520	.16	26	<25	---	1.4	13.2	4.2	73
ATLANTIC-RICHFIELD COMPANY, CORE BT-81												
D168825	5	<1	45	640	.13	35	<25	---	.3	15.0	5.0	120
D168826	12	<1	29	690	.15	31	<25	---	2.7	14.0	4.3	128
D168827	5	<1	22	460	.04	22	<25	---	<.1	11.0	3.8	74
D168828	30	<1	30	690	.68	34	<25	---	2.3	12.1	5.1	100
D168829	5	2.5	60	630	.42	32	<25	2.0	1.0	16.7	4.9	375
KERR-McGEE CORPORATION, CORE 3C-15												
D168830	4	<1	10	260	.02	11	<25	---	<.1	7.3	2.3	30
D168831	5	<1	20	740	.09	41	<25	---	1.0	13.2	5.1	100
D168832	10	<1	28	840	.09	34	<25	1.6	<.1	16.0	6.8	126
D168833	15	<1	25	580	.06	23	<25	1.8	<.1	9.2	4.5	100
D168834	5	<1	33	660	.09	39	<25	---	.9	13.3	5.4	100
D168835	5	<1	50	720	.07	50	25	---	.5	14.3	6.9	56
CARTER OIL COMPANY, CORE 97-C												
D168836	8	<1	20	440	.04	21	30	---	<.1	8.5	3.3	52
D168837	20	<1	32	650	.10	28	<25	---	.3	11.8	3.8	94
D168838	3	<1	24	510	.03	21	<25	---	<.1	12.4	4.9	47
D168839	10	<1	38	640	.08	41	30	2.9	.2	15.9	6.1	140
D168840	10	<1	29	660	.05	29	25	---	.3	16.0	5.6	91
D168841	10	<1	40	780	.08	35	25	---	<.1	18.3	5.5	104
CARTER OIL COMPANY, CORE 123-C												
D168842	25	<1	46	780	.50	33	30	1.8	1.3	12.1	4.5	54
D168843	8	<1	<10	250	.03	12	<25	---	<.1	4.3	2.5	23

selenium, but when the values for these samples are averaged with those of the other samples in the same core, their significance is seen to be minimal.

The analyses for an additional 17 trace elements are listed in Table 13d. Almost without exception, these values are about the same or less than the values for comparable sedimentary rocks elsewhere in the United States. None of the slightly higher analyses have significance when averaged with analyses of other samples from the same core.

The conclusion based on the chemical analyses of overburden rock samples is that no elements are present in amounts deserving special attention beyond that given to them in overburden rocks elsewhere. Based on the data, however, some of the carbonaceous shale and claystone units might be worth considering as sediment to be set aside during mining and then returned as topsoil; the slightly greater amounts of desirable micronutrient metals, phosphate, organic matter, and water retentivity may actually be preferable to those of the original soil. In examining trace element contents in any tables the reader is cautioned that samples from core hole, not outcrop, can be contaminated by drilling fluids and drill pipe. New equipment can result in anomalously high values for antimony, zinc, copper and lead. The presence or amount of toxic trace element in coal or overburden serves as a warning of a potential pollutant or contaminant upon the combustion of the coal or the disturbance, oxidation, and leaching of the overburden but does not necessarily indicate a level or degree of resultant toxicity. The form of the element and its interrelation with other elements, both before and after disturbance, oxidation or combustion, and leaching are important. During combustion of the coal trace elements may be emitted to the atmosphere in gas or particulate matter or may be concentrated in the ash. Trace elements may be emitted in

Table 13d

Semiquantitative Spectrographic Analyses (in parts per million) for 17 Additional Trace Elements[1] in 24 Samples of Rock Overburden Above Coal Beds to be Mined in the Eastern Powder River Basin, Campbell County, Wyoming. See Table 13a for further description of samples.

Sample No.	B	Ba	Be	Co	Cr	Ga	La	Mo	Nb	Ni	Sc	Sn	Sr	V	Y	Yb	Zr
PEABODY COAL COMPANY, CORE PH-C																	
D168820	30	500	<2	<5	50	30	<50	<5	15	7	10	<15	200	70	15	<2	100
D168821	30	500	<2	5	70	20	50	<5	15	10	10	<15	150	70	20	3	150
D168822	<30	500	<2	20	70	20	50	7	15	100	15	<15	100	100	20	2	100
D168823	50	500	<2	5	70	20	<50	<5	<10	10	10	<15	70	100	15	2	150
D168824	70	500	<2	5	70	30	<50	<5	15	15	10	<15	70	150	20	2	150
ATLANTIC-RICHFIELD COMPANY, CORE BT-81																	
D168825	50	700	<2	10	70	20	<50	<5	<10	20	10	<15	150	150	20	2	100
D168826	50	500	<2	10	70	20	<50	<5	<10	20	10	<15	150	100	20	2	100
D168827	30	500	<2	10	50	15	50	<5	<10	20	10	20	150	70	20	3	100
D168828	<30	1,000	<2	15	100	30	70	<5	<10	30	15	<15	150	150	20	2	70
D168829	50	500	<2	<5	100	30	<50	<5	15	10	15	<15	70	150	20	2	100
KERR-McGEE CORPORATION, CORE 3C-15																	
D168830	30	1,000	<2	<5	30	10	<50	<5	15	7	<5	<15	150	30	15	<2	100
D168831	50	700	<2	10	70	30	<50	<5	15	15	15	<15	200	150	20	2	100
D168832	50	700	<2	5	70	30	70	<5	15	15	15	<15	200	150	30	3	150
D168833	50	500	<2	5	50	15	70	<5	15	15	10	<15	150	20	20	2	150
D168834	50	500	<2	5	70	30	70	<5	15	15	15	<15	150	150	20	2	150
D168835	50	300	<2	5	100	30	50	<5	15	15	15	<15	150	150	20	2	100
CARTER OIL COMPANY, CORE 97-C																	
D168836	50	500	<2	5	30	15	<50	<5	<10	10	<5	<15	100	50	20	2	150
D168837	50	500	<2	10	50	20	70	<5	15	20	10	<15	150	70	30	3	150
D168838	50	700	<2	5	30	15	70	<5	15	15	7	<15	100	50	30	3	500
D168839	50	500	3	10	70	20	70	7	15	30	10	<15	150	150	20	2	100
D168840	50	300	<2	5	50	15	<50	7	15	20	10	<15	100	70	20	3	150
D168841	50	500	<2	10	70	20	70	<5	15	30	15	<15	100	150	20	3	100
CARTER OIL COMPANY, CORE 123-C																	
D168842	50	300	<2	<5	70	30	50	7	15	10	10	<15	70	150	15	<2	100
D168843	50	200	<2	<5	15	<10	70	<5	<10	<5	<5	<15	20	20	15	<2	300

---

[1] Some 20 additional trace elements were looked for, but were below the limit of detection using this analytical method; for example, it is thus known that all samples contain <2 ppm Ag, Au, and Pd, and <20 ppm Bi, Ge, and In.

dust from the overburden or concentrated in the disturbed rocks by oxidation or leaching. The emitted or concentrated element may be in an invert form or may be as free ions in solution. The amount of a toxic element in solution form is important, because in this form it may be easily ingested by plants and animals. The effects of long-term ingestion of low levels of these elements are poorly understood; most work on toxicity is based on high level exposure of short duration on small animals; extrapolation to humans, therefore, is uncertain.

Standards for acceptable levels of toxic trace elements pertaining to drinking water have been established by the World Health Organization, the U.S. Public Health Service, and the Federal Water Pollution Control Administration (Table 13e). Several water criteria reports containing discussions of trace elements are also listed in the selected references. Standards for acceptable levels or tolerance limits of toxicity for stack emissions or ash accumulations from coal-fired power generating plants and coal gasification and liquification plants have not been established for toxic trace metals.

Recently an exploratory study was set up to answer a specific geochemical question: do element levels in the sampled soils and plants decrease in a uniform way with increasing distance from a power generating plant?

Samples were collected from six localities parallel to, but away from, Interstate 25 at approximate distances of 0.8, 2.6, 6.6, 13.5, 26.4, and 53.8 kilometres from the Dave Johnston power plant. In each locality, two samples of surface soil (0-2.5 cm depth), subsurface soil (15-20 cm depth) and terminal leaves and stems of sagebrush were collected and analyzed by the U.S. Geological Survey for over 30 elements. Sufficient information was

Table 13e

Comparison of Chemical Constituents in the Drinking Water Standards of the World Health Organization and the U.S. Public Health Service

	Concentrations in Milligrams Per Liter						
	WHO International (1971)***			WHO European (1961)		U.S.P.H.S. (1962)	
Chemical Constituent	Permissible Limit(1958)	Highest Desirable Level	Maximum## Allowable	Recommended Limit	Tolerance Limit	Recommended Limit	Maximum Allowable
Alkyl benzene sulfonate	—	—	—	—	—	0.5	—
Ammonia (NIL)	—	—	—	0.5	—	—	—
Arsenic	—	—	0.05	—	0.2	0.01	0.05
Berium	—	—	—	—	—	—	1.0
Cadium	—	—	0.01	—	0.05	—	0.01
Calcium	75	200	—	—	—	—	—
Carbon chloroform extract	—	—	—	—	—	0.2	—
Chloride	200	600	—	350	—	250	—
Chromium (hexavalent)	—	—	0.05	—	0.05	—	0.05
Copper	0.05	1.5	—	3.0*	—	1.0	—
Cyanide	—	—	0.05	—	0.01	0.01	0.2
Fluoride	—	—	0.8-1.7###	1.5	—	0.8-1.7#	1.6-3.4#
Iron	0.1	1.0	—	0.1	—	0.3	—
Lead	—	—	0.10	—	0.1	—	0.05
Magnesium	150	150	—	125**	—	—	—
Magnesium + Sodium sulfate	30	1000	—	—	—	—	—
Manganese	0.05	0.5	—	0.1	—	0.05	—
Mercury	—	—	0.001	—	—	—	—
Nitrate (as NO_3)	—	—	—	50	—	45	—
Oxygen, dissolved (minimum)	—	—	—	5.0	—	—	—
Phenolic compounds (as phenols)	0.001	0.002	—	0.001	—	0.001	—
Selenium	—	—	0.01	—	0.05	—	0.01
Silver	—	—	—	—	—	—	0.05
Sulfate (SO_4)	200	400	—	250	—	250	—
Total Solids	500	1500	—	—	—	500	—
Zinc	5.0	15	—	5.0	—	5.0	—

*After 16 hours contact with new pipes; but water entering a distribution system should have less than 0.05 mg/1 of copper.

**If there are 250 mb/1 of sulfate present, magnesium should not exceed 30 mg/1.

***Based on average consumption of 2.5 liters by an individual weighing 70 kg.

#Recommended limits and maximum allowable concentrations vary inversely with mean annual temperature.

##Tentative upper limit or maximum permissible level.

###Depending on air temperature.

obtained to perform a standard regression, or trend, analysis on the following elements:

Surface and subsurface soil: Fe, Mg, Ca, Ti, Mn, Ba, Co, Cr, Cu, La, Nb (surface soil only, Ni, Pb, Sc, Sr, V, Y, Zr, Al, K, Ga, Yb, Th, and U.

Sagebrush ash: Fe, Mg, Ti, Mn, B, Ba, Cr, Cu, Mo, Ni, Pb, Sr, V, Zr, Al, P, Se (on dry weight), Li, Cd, Zn, and Co.

For each element in each material, a trend was computed in which the concentration of an element is predicted as a simple function of distance in kilometers from the power plant. The 95 percent standard statistical testing level indicates that Se, Sr, and V are most suspect as metal pollutants, particularly Se. Reductions in Co, Li, Ti, and Zn, while not as statistically significant as the previous three metals, should still be considered suspect.

This evaluation is a simple one, based on limited sampling, and further work is planned. The decrease away from the power plant is compelling, and the most likely source for the observed effects is stack emissions. The amounts of elements concentrated in sagebrush decrease rapidly from the power plant to about background level at 15 kilometers. Although a trend has been established the amounts of metals are not abnormal to contents in sagebrush in the entire Powder River Basin.

Considerable research has been done on certain trace elements such as selenium, cadmium, germanium, sulfur, uranium, vanadium, and flourine. A rare and useful trace element, germanium, is collected from power plant flue dust in England. Small amounts of selenium are actually required by enzymes in human metabolism. A trace amount of fluorine is commonly added to drinking water in many towns and cities to retard tooth decay of children. The National

Academy of Sciences are publishing a series of reports on the toxic trace metals (Vanadium, 1974; Selenium, 1971). In addition, the U.S. Geological Survey has a number of related trace element studies currently in progress in the major coal regions of western U.S. including the Powder River Basin: (1) coal; (2) coal-bearing rocks; (3) coal-related soils; (4) coal-related vegetation; (5) coal-related surface and ground waters. Reconnaissance trace metals surveys are being conducted by the U.S. Geological Survey in order to establish valid geochemical baselines for the major coal regions of the West. These studies encompass geochemical variations in rocks, soils, plants, and waters on a basinwide scale, presently centered on the Powder River Basin. Selenium converter plants and potential selenium problems are being studied on two projects. Problems related to element cycling, both natural and man-caused are being examined.

Some mining companies plan to replace overburden at the proposed surface mines in the same stratigraphic sequence as it is removed. It is recommended that all surface mines in the area be developed by this method. Overburden and coal at the mining face should be periodically sampled and analyzed for content of toxic trace elements.

TABLE I

DRILL HOLE LOCATION(S) OF SELECTED OVERBURDEN MATERIALS

BELLE AYR MINE

Hole #	Location
N-3	NW$\frac{1}{4}$ Sec. 3, T. 47 N., R. 71 W.
N-4	NE$\frac{1}{4}$ Sec. 33, T. 48 N., R. 71 W.
N-5	SW$\frac{1}{4}$ Sec. 28, T. 48 N., R. 71 W.
N-8	SW$\frac{1}{4}$ Sec. 27, T. 48 N., R. 71 W.
N-9	NW$\frac{1}{4}$ Sec. 4, T. 47 N., R. 71 W.
N-10	NW$\frac{1}{4}$ Sec. 33, T. 48 N., R. 71 W.
N-12	SE$\frac{1}{4}$ Sec. 29, T. 48 N., R. 71 W.
N-14	SE$\frac{1}{4}$ Sec. 32, T. 48 N., R. 71 W.

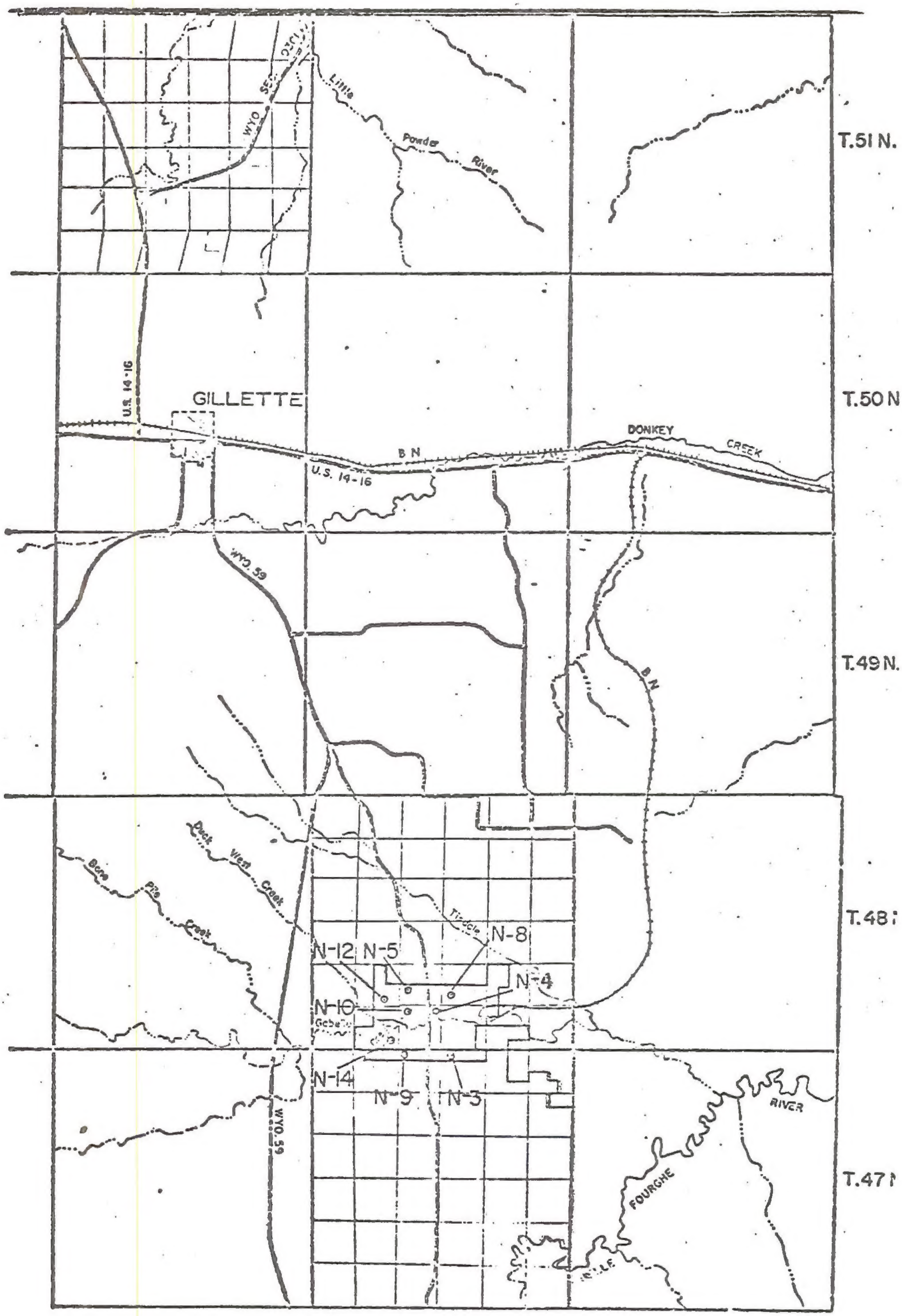

T.51 N.
T.50 N
T.49 N.
T.48
T.47
GILLETTE
U.S. 14-16
WYO.
Little
Powder
River
DONKEY
CREEK
B N
U.S. 14-16
WYO. 59
B N
Duck
West
Creek
Bone
Pile
Creek
N-8
N-12
N-5
N-4
N-10
N-14
N-9
N-3
WYO. 59
RIVER
FOURCHE
BELLE

Figure 1. Drill-hole locations from which overburden samples were taken within the Belle Ayr Mine.

Results and Interpretations:

The results of the various chemical determinations are compiled in Table (s) 2 through 7. Profile distribution trends of cation exchange capacity, pH, salinity parameters of electrical conductivity and sodium adsorption ratio, and available plant nutrients (NKP) are shown in Figures 3 through 10. Observations and their respective interpretative significance(s) are as follows:

Cation Exchange Capacity (CEC) (Table 2)

1. Review of the various profiles disclose relatively high CEC values for all shales and mudstones. CEC values average 16.8 meq/100g with maximum exceeding 30 meq/100g. Such high CEC values indicate ample plant nutrient availability. Review of Table 2 stands as factual evidence of such a statement. In addition, the high CEC values reflect high proportions of montmorillonite clay content. Figure 2 is a typical X-Ray diffractogram of the clays making-up the various shale overburden materials.

2. CEC values of unconsolidated sands and sandstones are considerably less than associated shales. CEC values within the clay-rich sandstone overburden materials average 8.5 meq/100g. Although such values are considered low, they are certainly above normal sandstone values which rarely exceed 5 meq/100g. As in the case of the associated shales, the predominant clay mineral is montmorillonite. Additional clay minerals present include (in order of relative abundance) kaolinite, illite, and expandable-mixed layered clays.

pH (Table 3)

Essentially all samples analyzed have pH values greater than 7. maximum and minimum values are 8.2 and 5.3 respectively. Such pH values are conducive to normal plant growth.

TABLE 2 - AMMONIUM ACETATE EXTRACTABLE CATIONS AND CATION EXCHANGE CAPACITY

SAMPLE NUMBER (BAS)	AMMONIUM ACETATE EXTRACTABLE CATIONS (meq/100g soil) Ca	Mg	Na	K	CEC (meq/100g)
1	15.00	5.00	1.31	0.33	4.99
2	22.60	4.40	1.26	0.33	5.32
3	37.70	8.10	1.14	0.58	16.93
4	40.25	8.35	2.29	0.63	34.72
5	23.15	8.35	2.07	0.72	26.91
6	19.55	7.85	2.09	0.81	20.83
7	15.00	5.95	1.85	0.74	17.79
8	13.05	5.00	1.87	0.75	19.96
9	13.90	5.75	2.09	0.79	18.66
10	14.20	5.75	2.12	0.82	19.96
11	11.80	4.35	1.80	0.70	18.88
12	29.70	3.80	0.25	0.54	13.02
13	32.00	5.60	3.11	0.48	18.65
14	34.15	6.95	3.87	0.52	27.78
15	35.85	6.60	3.38	0.52	27.34
16	36.35	5.75	2.34	0.57	20.83
17	22.45	5.30	0.66	0.41	7.05
18	11.70	3.10	0.39	0.34	11.94
19	5.60	1.35	0.22	0.31	2.80
20	4.75	1.70	0.27	0.32	2.60
21	3.10	1.10	0.28	0.31	1.34
22	7.30	1.70	0.34	0.31	3.15
23	7.55	1.90	0.38	0.31	3.73
24	3.75	1.20	0.34	0.30	0.95
25	3.25	1.00	3.11	0.32	1.34
26	14.40	5.40	0.81	0.58	14.97
27	20.00	7.00	1.11	0.65	19.96
28	18.10	3.30	0.48	0.63	17.14
29	13.35	3.25	0.78	0.36	14.76
30	7.55	2.30	0.83	0.31	7.81
31	7.60	2.45	1.05	0.32	5.42
32	14.20	3.25	1.05	0.33	7.59

TABLE 2 - (CONT.)

SAMPLE NUMBER (BAS)	AMMONIUM ACETATE EXTRACTABLE CATIONS (meq/100g soil) Ca	Mg	Na	K	CEC (meq/100g)
33	10.30	2.80	0.88	0.33	6.51
34	12.45	3.25	1.02	0.37	8.03
35	15.20	3.40	1.14	0.64	7.27
36	13.05	7.90	7.08	0.51	17.58
37	16.55	7.85	5.34	0.44	17.58
38	23.00	5.85	1.69	0.33	11.28
39	65.60	4.55	0.99	0.45	10.20
40	17.75	6.40	2.99	0.56	17.58
41	10.10	4.30	0.15	0.39	25.61
42	32.25	7.70	0.67	0.43	16.06
43	16.05	7.50	1.14	0.42	14.54
44	20.01	5.25	1.05	0.52	28.21
45	7.75	5.10	0.44	0.37	10.85
46	8.95	5.60	0.42	0.36	12.15
47	26.90	8.35	0.97	0.68	20.61
48	30.05	6.25	1.13	0.60	18.23
49	22.70	6.60	1.51	0.67	20.40
50	26.65	5.40	2.51	0.71	19.75
51	13.50	4.35	1.37	0.64	16.06
52	16.75	5.35	1.68	0.70	18.88
53	14.05	5.35	1.47	0.65	17.58
54	15.20	5.45	1.69	0.77	18.01
55	11.85	3.65	1.51	0.66	26.47
56	14.15	4.55	1.58	0.63	29.51
57	20.30	5.05	2.78	0.80	21.70
58	25.05	5.70	3.16	0.60	14.32
59	36.50	6.35	4.14	0.58	12.59
60	35.35	6.20	1.29	0.45	11.72
61	27.55	7.85	1.61	0.56	10.63
62	12.30	6.95	2.40	0.71	15.19
63	14.30	5.30	2.07	0.67	15.62
64	10.65	3.65	1.58	0.62	13.02
65	2.25	0.45	0.25	0.27	2.26
66	2.55	1.20	0.21	0.28	2.82
67	2.55	1.00	0.23	0.28	3.36
68	2.55	0.65	0.25	0.29	3.36
69	2.79	8.35	3.49	0.57	14.32
70	31.30	8.35	4.69	0.57	10.63
71	35.35	5.30	2.51	0.58	14.76
72	25.90	7.25	1.20	0.38	16.93
73	25.50	7.90	0.86	0.38	7.81
74	20.15	8.35	1.26	0.51	32.12

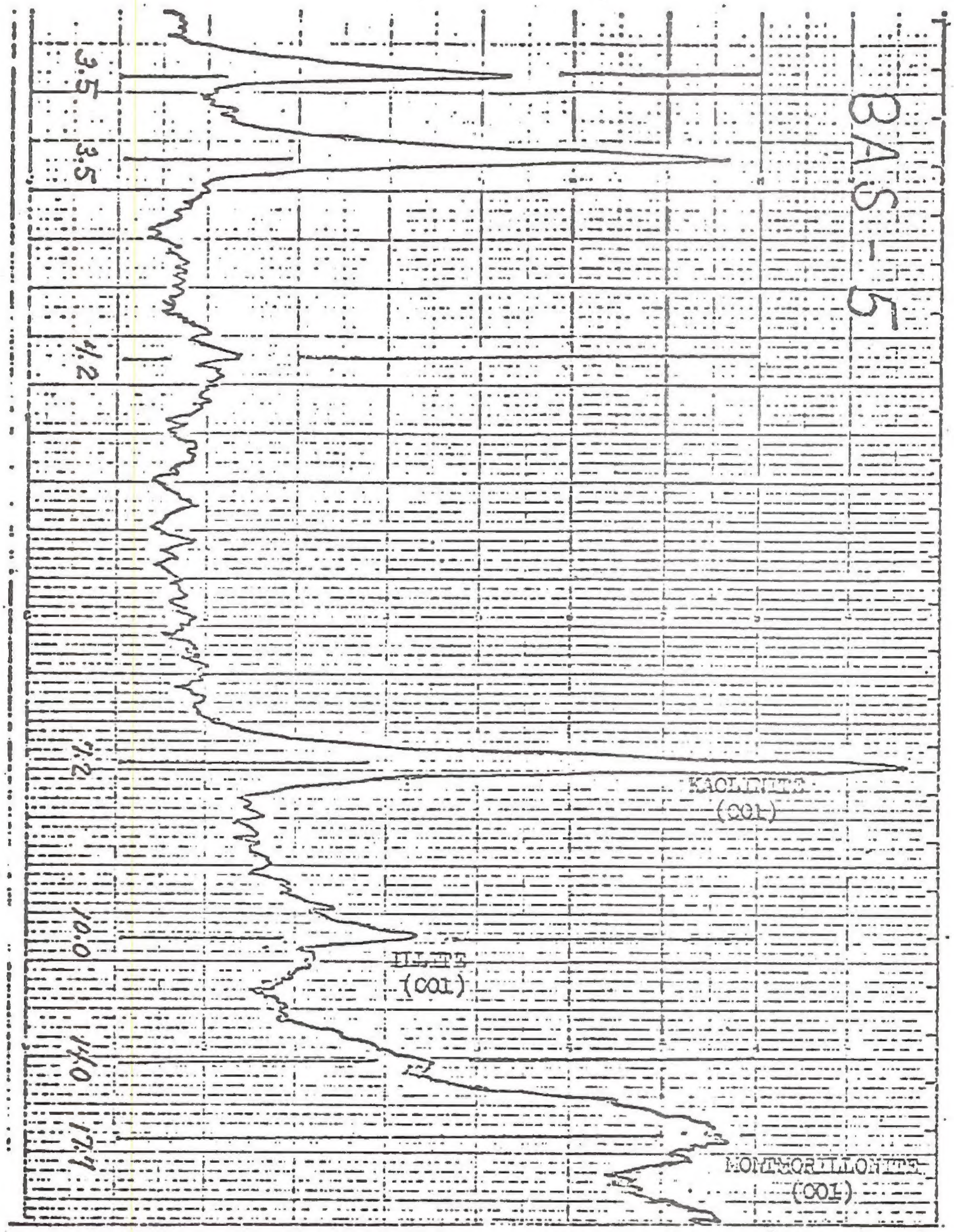


Figure 2 - Typical Clay X-Ray Diffractogram of Shale Overburden Material. (First order peaks in ascending order are montmorillonite, illite and kaolinite respectively.)

Salinity (See Table 3.)

1. Review of profiles (Figures 3-10) disclose higher E.C. (salinity indicator) and SAR (salinity and soil permeability indicator) values to occur within the upper 5 feet of present topography soils. This trend has significance from the standpoint of preferential handling and placement of potentially toxic overburden materials. Current base-line data suggests that present soils are less capable of sustaining adequate plant growth than underlying geologic materials. Of the total 74 samples analyzed, the respective maximum E.C. and SAR values of 6.2 millimhos/cm and 17.6 occur within the upper 5 feet of the soil horizon. Before any preferential mine handling and placement recommendations are made however, an in depth compare-contrast study of current topsoil (arbitrarily defined as upper 5 feet) versus overburden data must be made.

2. With exception to the upper 5 feet of soil, both E.C. and SAR values reflect minimal potential for creation of toxic saline and soil permeability if and when such materials are exposed during normal mine operations. E.C. values average less than 2 millimhos/cm. Maximum E.C. values, which rarely exceed 5.0 millimhos/cm, rate a mere slightly saline classification. SAR values are relatively low average 3.5. Review Table 4 (Water Soluble Cations in Saturation Extract), the low SAR values can be understood in that for most samples, the Ca++ plus Mg++/Na+ ratios are relatively high. Such ratios indicate that under present conditions, the clay minerals (montmorillonite and expandable-mixed layered clays) are saturated with Ca++ and Mg++. As long as such ratios are maintained within parent soil-forming material left after final reclamation grading, minimal problems related to soil permeability are anticipated.

TABLE 3 - SALINITY ANALYSIS

SAMPLE NUMBER (BAS)	pH paste	pH 1:5	E.C. paste mmhos	E.C. 1:5 mmhos	SATURATION %	SAR
1	8.1	7.9	3.69	0.78	38.9	6.1
2	8.0	7.7	2.88	1.13	39.4	4.7
3	7.2	7.6	2.26	0.92	58.2	3.3
4	5.8	6.4	2.35	1.58	63.2	3.2
5	6.3	6.6	3.01	1.51	67.9	3.7
6	6.7	6.9	1.61	0.91	69.0	3.1
7	7.7	7.8	1.06	0.62	73.7	4.0
8	8.0	7.6	0.59	0.22	73.7	3.9
9	7.6	7.5	0.82	0.31	79.9	7.5
10	8.0	7.7	0.68	0.33	80.9	5.4
11	7.2	7.3	0.69	0.27	81.3	4.7
12	7.6	7.9	1.62	0.26	45.3	0.3
13	8.1	8.2	2.09	0.54	53.6	7.3
14	7.9	7.9	2.49	0.88	61.1	7.1
15	7.9	7.8	2.50	1.35	65.6	6.1
16	7.7	7.7	2.80	1.29	64.2	3.9
17	7.8	7.7	1.61	0.33	47.9	2.2
18	7.7	7.8	1.85	0.34	38.6	1.3
19	7.8	7.7	0.77	0.13	24.4	1.7
20	8.0	7.8	0.71	0.13	30.7	2.0
21	8.1	7.6	1.01	0.13	24.0	2.8
22	7.8	7.7	1.90	0.27	26.9	2.0
23	7.9	7.8	1.95	0.30	26.5	2.6
24	8.2	7.6	1.49	0.19	26.1	3.2
25	8.1	7.6	1.89	0.20	24.3	2.4
26	6.2	7.2	1.70	0.78	10.6	2.0
27	7.4	7.5	1.63	0.56	72.2	2.2
28	7.1	7.6	3.40	0.52	34.3	0.9
29	7.9	7.9	2.69	0.54	25.9	5.3
30	8.0	7.8	1.99	0.29	26.0	3.9
31	8.0	7.7	1.49	0.38	25.9	3.1
32	8.0	7.8	2.24	0.50	27.6	3.9

TABLE 3 (CONT.)

SAMPLE NUMBER (RAS)	pH paste	pH 1:5	E.C. paste mmhos	E.C. 1:5 mmhos	SATURATION %	SAR
33	7.9	7.8	1.51	0.44	25.4	2.5
34	8.0	7.7	2.25	0.52	27.9	4.2
35	8.0	7.9	2.63	0.48	27.0	4.4
36	7.6	7.8	6.18	2.05	50.0	17.6
37	7.9	7.7	5.90	1.92	46.9	10.8
38	8.1	7.7	3.14	1.32	35.9	5.1
39	7.5	7.4	2.25	1.89	44.8	2.5
40	6.8	6.9	1.66	0.92	45.0	3.5
41	6.7	7.0	1.63	0.30	49.5	0.3
42	7.8	8.0	1.35	0.33	31.8	1.4
43	7.8	8.1	2.78	0.47	29.8	2.9
44	7.4	7.8	2.02	0.92	41.9	1.4
45	5.7	6.1	0.27	0.23	37.7	1.1
46	6.2	6.9	1.75	0.59	39.6	1.1
47	7.9	7.9	1.21	0.33	58.9	1.7
48	7.8	7.9	1.40	0.36	55.5	2.1
49	6.6	7.1	2.36	1.32	53.6	2.4
50	7.7	7.7	1.59	0.46	62.0	4.0
51	7.6	7.7	1.35	0.40	60.3	3.6
52	7.9	7.9	1.13	0.32	66.0	4.2
53	7.0	7.4	1.79	0.52	69.0	3.2
54	7.2	7.3	1.04	0.39	71.2	3.1
55	6.3	6.6	0.95	0.38	86.0	3.1
56	5.3	5.5	2.10	0.74	84.3	2.9
57	7.4	7.5	4.04	1.00	44.0	5.7
58	8.1	7.9	4.21	1.39	38.5	8.5
59	8.3	7.9	4.81	2.41	43.2	1.1
60	7.6	7.7	2.79	1.82	42.5	3.0
61	7.9	7.8	2.08	0.86	49.8	3.7
62	8.2	8.0	0.92	0.39	70.3	4.5
63	7.9	7.8	1.00	0.34	73.6	6.0
64	7.8	7.8	1.00	0.33	78.5	4.2
65	7.6	7.2	0.86	0.10	24.1	2.3
66	5.4	5.5	0.69	0.10	24.9	1.3
67	5.0	5.1	0.41	0.06	28.7	1.7
68	5.0	5.2	0.34	0.04	29.6	2.2
69	8.0	7.7	5.60	2.51	69.2	0.7
70	8.2	8.1	5.10	1.39	74.8	0.9
71	7.8	7.8	2.95	1.52	72.6	3.7
72	7.9	7.9	3.38	0.99	55.2	3.0
73	7.6	7.8	3.13	1.10	47.7	2.2
74	5.3	5.8	2.41	1.02	55.0	2.2

E.C. - Electrical Conductivity
SAR - Sodium Adsorption Ratio

TABLE 4 - WATER SOLUBLE CATIONS IN SATURATION EXTRACT

SAMPLE NUMBER (BAS)	SATURATION EXTRACT CATIONS - meq/liter				TOTAL
	Ca	Mg	Na	K	
1	16.33	15.80	24.35	0.33	56.81
2	14.48	14.21	17.82	0.33	46.84
3	13.63	11.25	11.52	0.46	36.86
4	13.35	12.10	11.52	0.57	37.54
5	18.60	13.49	15.00	1.02	48.11
6	9.51	6.40	8.70	0.74	25.35
7	4.12	2.68	7.35	0.60	14.75
8	2.27	1.25	5.13	0.95	9.60
9	3.12	1.56	11.52	0.50	16.70
10	1.56	0.80	5.87	0.41	8.64
11	1.68	1.09	5.56	0.44	8.77
12	15.05	4.45	0.91	0.33	20.74
13	7.24	8.34	20.43	0.26	36.27
14	10.79	11.00	23.48	0.31	45.58
15	15.76	12.49	23.04	0.33	51.62
16	23.15	13.10	16.52	0.43	53.20
17	10.22	6.44	6.48	0.34	23.48
18	13.63	7.11	4.17	0.32	25.23
19	5.11	2.89	3.48	0.30	11.78
20	4.83	2.50	3.91	0.38	11.62
21	4.83	3.98	5.87	0.42	15.10
22	14.20	7.41	6.56	0.45	28.62
23	15.76	9.35	9.13	0.46	34.70
24	9.23	7.11	9.09	0.50	25.93
25	14.63	8.60	8.26	0.56	32.05
26	14.77	7.39	6.78	1.29	30.23
27	12.64	6.52	6.69	0.83	26.68
28	33.65	9.21	4.35	0.57	47.78
29	17.89	9.02	19.56	0.70	47.17
30	13.63	6.94	12.61	0.40	33.58
31	11.64	5.62	9.22	1.10	27.58
32	17.32	8.79	14.13	0.41	40.65
33	16.33	7.08	8.69	0.42	32.52

TABLE 4 (CONT.)

SAMPLE NUMBER (BAS)	SATURATION EXTRACT CATIONS - meq/liter				TOTAL
	Ca	Mg	Na	K	
34	18.03	8.51	15.22	0.56	42.32
35	19.60	9.05	16.52	0.48	45.65
36	13.06	17.50	68.69	0.32	99.57
37	14.34	17.81	43.48	0.34	75.97
38	19.31	14.20	20.87	0.28	54.66
39	20.16	10.25	9.56	0.61	40.58
40	10.79	5.48	10.00	0.57	26.84
41	13.49	6.47	1.02	0.19	21.17
42	9.94	6.01	3.91	0.30	20.16
43	18.74	12.42	11.56	0.55	43.27
44	17.18	10.18	5.22	0.37	32.95
45	6.25	3.42	2.39	0.28	12.34
46	16.33	10.22	3.91	0.39	30.85
47	10.22	5.30	4.78	0.54	20.84
48	13.77	4.84	6.35	0.52	25.48
49	25.28	9.30	10.09	0.82	45.49
50	10.78	3.74	10.78	0.73	26.03
51	9.94	2.73	9.13	0.64	22.44
52	7.81	2.01	9.22	0.57	19.61
53	14.34	5.79	10.00	0.71	30.84
54	7.38	2.12	6.74	0.52	16.76
55	6.82	1.78	6.35	0.44	15.39
56	20.87	6.88	10.78	0.60	39.13
57	27.26	14.20	25.65	0.52	67.63
58	17.04	15.40	34.35	0.46	67.25
59	17.89	15.99	4.56	0.50	38.94
60	24.71	10.88	12.56	0.44	48.59
61	13.06	9.68	12.60	0.82	36.16
62	5.82	1.78	8.69	0.47	16.76
63	7.24	1.42	12.56	0.58	21.80
64	8.66	1.64	9.56	0.66	20.52
65	8.66	1.70	5.30	0.31	15.97
66	6.53	1.84	2.69	0.32	11.38
67	4.40	0.34	2.69	0.23	7.66
68	3.41	0.10	2.91	0.30	6.72
69	22.15	17.80	3.35	0.96	44.26
70	18.89	16.39	3.78	0.79	39.85
71	18.46	14.00	15.00	0.65	48.11
72	22.86	14.99	13.04	0.63	51.52
73	20.16	15.80	9.22	0.59	45.77
74	19.31	14.21	9.13	0.56	43.21

TABLE 5 - WATER SOLUBLE ANIONS IN SATURATION EXTRACT

SAMPLE NUMBER (BAS)	SATURATION EXTRACT ANIONS - meq/liter					TOTAL
	CO_3	HCO_3	Cl	SO_4	NO_3	
1	0.0	3.33	15.79	42.88	2.20	64.20
2	0.0	3.62	12.69	37.19	1.80	55.30
3	0.0	3.74	9.87	25.44	2.86	41.57
4	0.0	3.64	11.14	24.38	4.91	44.07
5	0.0	3.47	14.10	36.00	4.56	58.13
6	0.0	3.46	11.28	18.94	2.18	35.86
7	0.0	3.64	10.58	12.00	1.20	27.42
8	0.0	3.67	9.45	8.75	0.86	22.73
9	0.0	3.47	10.29	10.00	1.49	25.25
10	0.0	3.60	10.58	4.31	1.38	19.87
11	0.0	3.60	11.56	7.38	1.04	23.58
12	0.0	4.41	16.92	3.81	0.64	25.78
13	0.0	3.82	12.69	21.25	0.44	38.20
14	0.0	3.65	19.32	26.44	0.66	50.07
15	0.0	3.64	13.25	35.62	0.77	53.28
16	0.0	4.09	19.04	26.06	0.59	49.78
17	0.0	4.28	17.63	8.75	0.34	31.00
18	0.0	4.05	20.73	9.25	0.70	34.73
19	0.0	4.09	7.05	9.44	0.21	20.74
20	0.0	4.50	6.20	8.75	1.42	20.87
21	0.0	5.36	7.76	9.31	0.62	23.05
22	0.0	4.68	12.13	17.62	0.54	34.94
23	0.0	4.77	10.86	23.94	1.05	40.62
24	0.0	4.90	6.63	20.00	0.93	32.46
25	0.0	2.92	6.63	26.31	1.64	37.17
26	0.0	2.88	10.72	26.19	0.99	40.78
27	0.0	3.22	9.87	24.31	1.21	38.61
28	0.0	3.51	38.21	11.94	0.25	53.91
29	0.0	3.19	11.00	25.94	0.48	40.61
30	0.0	3.31	5.50	22.81	0.86	32.22
31	0.0	3.78	8.46	30.62	0.70	43.56
32	0.0	4.05	5.92	26.81	0.67	37.45

TABLE 5 - (CONT.)

SAMPLE NUMBER (BAS)	SATURATION EXTRACT ANIONS - meq/liter CO_3	HCO_3	Cl	SO_4	NO_3	TOTAL
33	0.0	3.78	6.35	58.75	0.84	69.59
34	0.0	3.56	7.61	30.94	0.84	42.95
35	0.0	3.42	9.31	31.25	0.55	44.51
36	0.0	3.73	22.84	56.19	0.56	84.03
37	0.0	3.53	19.04	60.31	0.31	83.19
38	0.0	3.74	13.40	40.63	0.57	58.34
39	0.0	3.87	10.58	28.25	1.10	39.93
40	0.0	4.57	14.10	22.44	0.41	41.52
41	0.0	4.05	20.59	2.31	0.41	27.36
42	0.0	3.87	14.81	7.50	0.35	26.53
43	0.0	3.96	22.56	22.38	0.00	57.80
44	0.0	4.63	12.69	20.13	1.01	38.46
45	0.0	4.45	10.43	11.94	0.49	27.31
46	0.0	4.16	7.47	28.50	0.81	40.94
47	0.0	5.31	7.76	18.44	0.59	32.10
48	0.0	4.61	8.46	19.31	0.62	33.00
49	0.0	2.90	10.29	30.63	0.99	44.81
50	0.0	1.89	11.70	15.88	0.75	30.22
51	0.0	2.09	14.81	7.56	0.17	24.63
52	0.0	2.30	5.92	13.12	0.34	21.56
53	0.0	2.65	9.17	23.12	0.21	35.08
54	0.0	1.98	9.17	12.06	0.30	23.51
55	0.0	1.94	7.05	13.12	0.34	22.45
56	0.0	2.07	9.87	29.31	0.38	14.63
57	0.0	3.33	31.73	28.56	0.16	35.78
58	0.0	2.27	22.56	41.38	0.18	66.31
59	0.0	2.12	11.99	55.94	0.49	60.54
60	0.0	2.61	19.74	28.81	0.65	51.81
61	0.0	3.13	6.35	29.94	1.72	41.14
62	0.0	2.34	9.02	12.50	0.88	24.74
63	0.0	2.14	9.17	13.44	0.66	25.41
64	0.0	2.30	6.35	13.69	1.08	23.42
65	0.0	2.14	9.17	7.81	0.66	19.78
66	0.0	2.07	11.42	6.88	0.29	20.66
67	0.0	1.98	13.40	4.38	0.20	19.96
68	0.0	2.16	9.31	3.81	0.27	15.55
69	0.0	2.79	14.10	95.62	0.16	112.67
70	0.0	3.35	11.84	91.62	2.38	109.19
71	0.0	3.06	11.28	35.94	6.11	56.39
72	0.0	2.99	12.13	40.81	5.88	61.81
73	0.0	3.89	8.60	43.06	4.31	59.86
74	0.0	4.12	7.33	37.50	1.27	50.22

3. Shales and/or mudstones possess slightly higher SAR values than associated sandstones. This has significance from the standpoint of future agronomic land-use. If left as parent soil-forming material, the shale because of higher montmorillonite clay content will be more susceptible to an increase in SAR especially if crop irrigation methods are used. Continued surveillance of Ca++ plus Mg++/Na+ ratios within such materials will be required in order to assure maintance of greater concentrations of Ca++ and Mg++. The objective to maintain such ratios may be accomplished in the following ways:

a) Ca++ plus Mg++ "Hardening Treatment" of irrigation waters prior to field application.

b) Frequent lime applications.

Plant Nutrients (NKP) and Micronutrients (Zn, Fe, Cu, Mn) (See Table 6.)

Nitrogen (NO_3-N). The majority of samples analyzed are deficient in available nitrogen for normal plant growth. Of the total 74 samples, 7 samples had anomalously high concentrations of available nitrate-nitrogen (See Figures 3 and 6.) These anomalous values are understood with referral to original field descriptions of respective samples (Appendix A.) All samples containing high nitrogen values possess high carbonaceous and coal fragment contamination. Regardless of type-material left at the surface following mining, Nitrogen Fertilization will be required. Although recommendations with regard to quantity of fertilization must follow evaluation of materials left at the surface following restoration grading, present base-line data can be used to calculate approximate cost factors to be included in mining cost projections.

Phosphorus (P). As with the case of nitrogen the majority of samples analyzed are deficient in available phosphorus for normal plant growth.

TABLE 6 - PLANT NUTRIENTS

SAMPLE NUMBER (BAG)	NO_3-N ppm	P ppm	K ppm	Zn ppm	Fe ppm	Cu ppm	Mn ppm
1	2.9	2.5	128	3.36	7.2	1.32	5.07
2	11.2	1.3	128	3.33	7.2	1.24	6.78
3	79.0	10.8	225	7.38	44.6	2.75	9.71
4	201.7	6.8	245	65.80	221.2	2.98	7.85
5	170.3	5.3	280	18.52	84.0	4.43	5.85
6	92.6	4.3	318	32.94	97.0	4.76	7.98
7	32.3	2.8	288	18.73	67.4	5.01	13.57
8	13.7	4.5	295	28.63	39.6	5.75	5.19
9	32.9	1.8	310	31.78	46.7	6.41	8.51
10	18.6	2.5	320	69.30	46.0	6.41	6.65
11	3.5	2.3	275	22.23	34.0	7.10	4.39
12	5.4	8.8	213	156.45	7.6	1.21	16.23
13	4.8	2.8	188	34.79	36.4	1.32	27.13
14	7.8	3.8	205	11.55	16.4	2.01	14.10
15	9.8	3.3	205	9.66	36.0	2.20	11.17
16	12.3	6.3	223	8.44	19.0	2.75	13.30
17	3.3	5.3	160	5.60	26.4	1.61	11.44
18	2.4	5.0	133	3.71	12.0	0.92	5.45
19	0.0	1.5	123	4.27	7.0	0.95	2.13
20	0.0	1.0	125	7.88	18.4	0.99	3.06
21	0.0	0.2	123	2.80	9.6	0.66	1.69
22	0.0	1.5	123	4.06	10.0	0.95	3.59
23	2.7	1.0	120	5.74	13.0	0.92	4.39
24	0.8	1.0	118	1.92	5.0	0.88	3.19
25	0.7	0.8	125	2.80	5.2	0.62	2.66
26	1.0	1.3	225	10.33	42.0	4.10	6.38
27	1.3	0.8	253	13.86	22.4	5.67	6.78
28	3.3	10.2	248	2.59	25.4	1.68	13.83
29	1.4	4.8	143	2.00	19.0	1.40	7.98
30	1.6	4.5	123	3.68	18.4	1.21	8.11
31	1.7	3.5	125	3.92	21.4	1.10	7.98
32	1.6	4.3	130	2.66	15.0	0.99	6.92

TABLE 6 - (CONT.)

SAMPLE NUMBER (BAS)	NO_3-N ppm	P ppm	K ppm	Zn ppm	Fe ppm	Cu ppm	Mn ppm
33	3.5	4.5	130	3.01	19.0	0.95	9.44
34	1.5	4.5	145	6.72	18.0	1.32	6.25
35	0.9	4.2	143	5.46	20.0	1.21	7.18
36	0.0	21.5	200	98.00	20.4	3.04	16.23
37	0.0	9.8	170	4.24	16.0	2.60	8.51
38	0.0	5.0	128	2.31	12.4	2.27	6.92
39	1.3	5.3	175	137.90	43.6	2.60	12.24
40	0.0	4.5	218	16.63	44.4	11.05	16.63
41	2.1	4.5	153	4.41	20.0	1.79	11.31
42	3.2	9.5	168	2.24	13.2	1.10	4.39
43	0.6	10.0	165	1.23	15.0	1.02	6.12
44	4.8	5.5	203	4.83	17.4	3.07	3.06
45	1.1	4.0	145	9.45	41.6	2.85	6.12
46	1.3	9.5	143	6.30	133.0	3.11	2.13
47	1.1	2.5	268	17.01	57.0	5.67	32.59
48	1.7	3.8	233	8.82	53.0	4.32	32.85
49	3.5	6.3	263	16.52	99.6	5.64	29.13
50	3.1	6.5	278	10.68	146.8	6.44	64.77
51	5.2	10.0	250	15.89	91.6	7.06	23.99
52	2.0	3.5	273	23.52	144.4	6.44	35.51
53	3.6	6.5	255	17.12	79.2	5.45	35.64
54	2.4	4.5	300	24.15	60.4	6.88	21.41
55	1.5	5.0	258	15.26	44.4	8.27	7.32
56	0.0	2.5	245	20.02	207.0	12.41	15.96
57	2.3	22.8	313	33.85	19.6	2.45	17.29
58	0.0	12.0	233	1.75	16.0	2.20	6.92
59	0.7	5.5	225	2.35	18.6	2.67	6.25
60	1.7	5.2	175	6.02	15.2	1.87	24.21
61	1.5	2.3	220	33.11	69.0	5.97	23.28
62	0.0	3.0	278	22.47	57.0	7.14	8.51
63	0.0	1.5	263	30.52	56.4	7.21	8.25
64	1.0	1.2	243	18.73	37.6	5.78	3.72
65	0.6	6.5	105	3.15	6.0	0.88	0.80
66	0.3	7.8	108	10.57	19.2	1.06	0.93
67	0.0	7.5	108	14.88	55.2	1.21	2.66
68	0.0	8.0	113	80.85	73.2	1.46	5.45
69	2.4	4.8	223	2.28	31.6	3.00	35.11
70	66.4	4.5	223	3.71	49.0	3.77	40.30
71	246.6	10.0	228	1.86	28.8	3.44	28.99
72	146.4	7.5	150	1.61	31.6	2.42	43.36
73	67.4	4.8	150	16.84	40.8	3.48	19.95
74	20.3	12.2	200	20.16	390.0	9.52	17.82

As a generalization, regardless of type soil-forming material left at the surface following reclamation grading, phosphorus fertilization will be required. Present base-line data can be utilized to calculate approximate cost factors to be included in mining cost projections.

Potassium (K). All overburden samples possess sufficiently high concentrations of available potassium for normal plant growth. In comparing sandstones versus shale, the shale and/or mudstone within the overburden have essentially twice as much available potassium. The illite and montmorillonite clay content of the shaly materials are the major contributors of potassium. Illite, montmorillonite, and feldspar sand grains are the major contributors in unconsolidated sand and sandstone. Based upon data available, NO POTASH (K_2O) FERTILIZATION WILL BE NEEDED.

Micronutrients (Zn, Fe, Cu, Mn). Review of Table 4 discloses relatively high concentration levels of the micronutrients of zinc (Zn), Iron (Fe), Copper (Cu), and manganese (Mn). AVAILABILITY IS SUCH THAT NO MICRONUTRIENT AMENDMENTS WILL BE REQUIRED.

Total Sulfur (See Table 7.) With exception to 5 samples which possess total sulfur (S) values greater than 1.0%, all remaining samples contain total sulfur concentrations which rarely exceed 0.3 percent. Of the maximum values observed, only two samples (BAS-26 and 27, Appendix A) were observed to contain fine-grain pyrite (FeS_2). The other three samples contain sufficient quantities of gypsum ($CaSO_4 \cdot 2H_2O$) and carbonaceous matter to account for the total sulfur measured. As a general statement, the major source(s) of sulfur within the overburden are soluble sulfate-salts and gypsum crystals. The relatively high sulfate ($SO_4^{=}$) concentrations (20-40 meq/liter) (see Table 5) serve as factual evidence of the preceding statements. To briefly summarize, NO TOXIC ACIDITY CONDITIONS ARE ANTICIPATED. To the contrary, available pyrite-sulfur present can be utilized to keep the alkalinity level within the acceptable pH ranges of 6.5-8.00.

Trace Elements (Cd, Pb, Hg) (See Table 7.)

1. Because there exists no established guidelines pertaining to acceptable cadmium (Cd), lead (Pb), and mercury (Hg) in overburden materials at present time, evaluation of such data is somewhat difficult. However, if one makes the reasonable assumption that geologic materials exposed at the surface are major contributors of contaminants to streams draining affected areas, water quality limits may be a starting point for evaluating the overburden data. If current proposed Federal toxic standards for cadmium (≤ 0.040 ppm) and mercury (≤ 0.02 ppm) are used, 70 percent of the overburden samples analyzed have values exceeding the proposed concentration limits. For all samples, cadmium (Cd) and mercury (Hg) average 0.233 ppm and 0.084 ppm respectively. This cadmium level exceeds proposed Federal limits by a factor of twenty and the mercury value exceeds the Federal limit by a factor of four. If the above Federal legislation is approved, we may anticipate future problems meeting mine effluent standards based upon the observed trace element concentration levels within the overburden. NEEDLESS TO SAY, IF SIMILAR TOXIC STANDARDS ARE EVENTUALLY ESTABLISHED FOR OVERBURDEN MATERIALS, SURFACE MINING IN THE STATE OF WYOMING MAY BE IN JEOPARDY.

Although the proposed Federal water quality standards do not include a toxic limit on lead (Pb), one part per million/liter is accepted by the State of Illinois as the upper concentration level for

TABLE 7 - Total Sulfur, Cadmium, Lead and Mercury Determinations

SAMPLE NUMBER (BAS)	TOTAL SULFUR %	CADMIUM ppm	LEAD ppm	MERCURY ppm
1	0.197	0.050	0.513	0.098
2	0.375	0.050	0.304	0.161
3	0.429	0.104	0.380	0.214
4	1.025	0.715	0.475	0.187
5	0.598	0.510	0.437	0.053
6	0.029	0.343	0.247	0.102
7	0.010	0.387	0.418	0.120
8	0.263	0.685	0.969	0.115
9	0.145	0.285	0.684	0.158
10	0.025	0.025	0.418	0.094
11	0.011	0.290	0.760	0.146
12	0.119	0.029	0.266	0.031
13	0.166	0.027	0.190	0.046
14	0.010	0.027	0.152	0.048
15	0.004	0.038	0.114	0.051
16	0.144	0.045	0.133	0.068
17	0.137	0.033	0.304	0.080
18	0.047	0.058	0.627	0.041
19	0.036	0.021	0.494	0.027
20	0.043	0.023	0.475	0.033
21	0.062	0.017	0.665	0.032
22	0.030	0.020	0.570	0.030
23	0.091	0.026	0.703	0.023
24	0.021	0.014	0.520	0.012
25	0.056	0.015	0.390	0.012
26	1.024	0.136	0.370	0.230
27	1.034	0.202	0.399	0.298
28	0.648	0.039	0.798	0.018
29	0.175	0.052	0.209	0.018
30	0.059	0.034	0.304	0.020
31	0.150	0.045	0.210	0.018
32	0.218	0.046	0.135	0.012
33	0.089	0.045	0.086	0.025
34	0.129	0.094	0.076	0.020
35	0.118	0.040	0.786	0.017
36	0.304	0.415	0.139	0.042
37	0.484	0.240	0.117	0.031
38	0.318	0.228	0.109	0.015
39	2.048	0.333	0.626	0.065
40	0.456	0.458	2.128	0.046
41	0.142	0.146	0.038	0.018
42	0.149	0.125	0.100	0.009
43	0.180	0.174	0.106	0.011
44	0.156	0.123	0.580	0.018
45	0.103	0.114	0.335	0.045
46	0.349	0.115	0.085	0.088

TABLE 7 - (CONT.)

SAMPLE NUMBER (BAS)	TOTAL SULFUR %	CADMIUM ppm	LEAD ppm	MERCURY ppm
47	0.476	0.397	0.313	0.191
48	0.360	0.165	0.518	0.150
49	1.135	0.518	0.370	0.266
50	0.301	0.254	0.568	0.142
51	0.154	0.237	0.487	0.209
52	0.454	0.336	0.247	0.147
53	0.369	0.332	0.276	0.215
54	0.034	0.300	0.255	0.119
55	0.030	0.275	1.615	0.197
56	0.395	0.493	0.931	0.245
57	0.020	0.272	0.276	0.056
58	0.029	0.268	0.230	0.016
59	0.059	0.199	0.299	0.023
60	0.010	0.300	0.441	0.045
61	0.011	0.436	0.652	0.119
62	0.012	0.300	0.157	0.178
63	0.020	0.886	0.950	0.141
64	0.010	0.219	0.409	0.111
65	0.041	0.009	0.314	0.031
66	0.030	0.009	0.247	0.039
67	0.010	0.015	0.321	0.019
68	0.020	0.011	0.475	0.035
69	0.585	0.097	0.616	0.080
70	0.299	0.016	0.152	0.059
71	0.294	0.020	0.133	0.074
72	0.281	0.046	0.133	0.049
73	0.046	0.258	0.456	0.070
74	0.316	0.747	0.342	0.167

mine effluent. With exception to one sample, (see Table 7, BAS-40) which had a measured lead (Pb) concentration of 2.128 ppm, all overburden samples analyzed have lead concentrations less than 1 ppm. For all samples, lead (Pb) ranges from 0.038 to 2.128 ppm and averages 0.42 ppm. Based upon the current base-line data, the 1 ppm lead limit appears to be a realistic figure for Wyoming geologic materials.

2. If and when Federal legislation attempts to attach toxic standards to trace elements in overburden, the base-line data obtained from this study can be used in establishing realistic guidelines possessing geographic ramifications.

APPENDIX F

Selected Water Data

Page

Part 1 - Water Rights Data F-2

Part 2 - Streamflow Data F-12

Part 3 - Infiltrometer Test Results F-15

Source: Amax Coal Company Continuing
Environmental Research Studies

```
                         WYOMING  WATER  RIGHTS                                              PAGE    9

1)       PERMIT               P4246
2)       DIVISION             2
3)       DISTRICT             CAMPBELL
4.1)     APPLICANT
                              CASSIDY, JAMES M.
                               GILLETTE,WY
6)       FACILITY             CASSIDY #1
7)       USE                  IRR
8.1)     WELL LOCATION
 46  071  25
9.1)     TYPE WELL            DRIL                   X
10)      DEPTH WELL               47.00  FEET
11)      STATIC WATER             10.00  FEET
12)      DIAMETER               * 15.00  INCHES
13)      YIELD                   350.00  GPM
14)      TOP ZONE                 10.00  FEET
15)      BOTTOM ZONE              15.00  FEET
16)      FIRST WZ                 10.00  FEET
17)      CLAIMED                 500.00  GPM
18.1)    COMPLETION DATE      12/1 /1955
19.1)    BENEFICIAL USE       12/16/1955
20)      PRIORITY DATE        01/10/1956
23)      NOTICES
                              $ - COMPLETION FILED IN GOOD STANDING
                              * - BENEFICIAL USE FILED IN GOOD STANDING
24)      WELL LOG             Y
26.1)    LAND
 46  071  25
                                      4.6    22.8    4.6    .2
                                                                        LAND TOTALS                        32.4
                                                                          UNADJUDICATED                  32.40
```

```
                         WYOMING  WATER  RIGHTS                                  02/06/74        PAGE    16

1)        CERTIFICATE         C43/347
2.1)     PERMIT               P6705R
3)       DIVISION             2
4)       DISTRICT             10
5.1)     PROOF                27007
6.1)     APPROPRIATOR
                              CLABAUGH, LESLIE
                              GILLETTE, WY
7)       FACILITY             CLABAUGH STOCKWATER RES
8)       USE                  STO
9)       SOURCE               CLABAUGH DR
10.1)    TRIBUTARY            HORSE CR
                              CABALLO CR
10.2)    TRIBUTARY            BELLE FOURCHE R
10.3)    TRIBUTARY            CHEYENNE R  SD
13)      PRIORITY DATE        06/25/1962
15.1)    OUTLET
 47  071  03
16.1)    ADJUDICATED AC-FT         36.50  ACRE-FEET          X
22.1)    CERT/ORDER RECORD    016/379
23)      NOTICES
                              T - TRIBUTARIES INCOMPLETE ~~OR INACCURATE~~ ON RECORD
25)      HEIGHT OF DAM             21.60  FEET
27.1)    LAND
 47  071  03
```

```
                       . WYOMING  WATER  RIGHTS                                  02/07/74        PAGE    17

1)        PERMIT              P5505P
3)       DIVISION             2
4)       DISTRICT             CAMPBELL
5.1)     APPLICANT
                              CLABAUGH, LESLIE
                              TECKLA RTE.
                              GILLETTE, WY
7)       FACILITY             HARPER #1
8)       USE                  STO
9.1)     WELL LOCATION
 49  071  2
10.1)    TYPE WELL            DUG                                    X
11)      DEPTH WELL                10.00  FEET
12)      STATIC WATER               9.00  FEET
14)      YIELD                     10.00  GPM
16)      APPROVAL DATE        05/25/1970
19.1)    COMMENCEMENT DATE    06/00/1922
20.1)    COMPLETION DATE      06/00/1922
21.1)    BENEFICIAL USE       06/00/1922
22)      PRIORITY DATE        12/31/1922
26)      WELL LOG             Y
27.1)    LAND
 48  071  2
```

```
                              WYOMING  WATER  RIGHTS                                02/06/74            PAGE   17

 1)        CERTIFICATE            C43/348
 2.1)      PERMIT                 P53865
 3)        DIVISION               2
 4)        DISTRICT               10
 5.1)      PROOF                  27668
 6.1)      APPROPRIATOR
                                  CLABAUGH, LESLIE C.
 6.2)      APPROPRIATOR           GILLETTE, WY

                                  CLABAUGH, BLANNIE A.
 7)        FACILITY               GILLETTE, WY
 8)        USE                    DEWITT STOCK RES -
 9)        SOURCE                 STO
 10.1)     TRIBUTARY              DEWITT DR
                                  HORSE CK
 10.2)     TRIBUTARY              LABELLE CK
 10.3)     TRIBUTARY              BELLE FOURCHE R
 13)       PRIORITY DATE          CHEYENNE R  SD
 16.1)     OUTLET                 10/01/1965
  47  071  13
 18.1)     ADJUDICATED AC-FT              1.95  ACRE-FEET
 22.1)     CERT/ORDER RECORD      016/378
 25)       HEIGHT OF DAM          PIT
 25.1)     EXPLANATION            RECORD CARRIES TRIB AS HORSE CK
 27.1)     LAND
  47  071  13
```

```
                              WYOMING  WATER  RIGHTS                                02/07/74            PAGE   18

 1)        PERMIT                 P5510P
 3)        DIVISION               2
 4)        DISTRICT               CAMPBELL
 5.1)      APPLICANT

                                  CLABAUGH, LESLIE
                                  TECKLA RTE.
 7)        FACILITY               GILLETTE, WY
 8)        USE                    EARL #1
 9.1)      WELL LOCATION          STO
  45  071  .:   A
 10.1)     TYPE WELL              DRIL
 11)       DEPTH WELL                    55.00  FEET
 12)       STATIC WATER                  35.00  FEET
 13)       DIAMETER                       6.00  INCHES
 14)       YIELD                          4.00  GPM
 18)       APPROVAL DATE          05/25/1970
 19.1)     COMMENCEMENT DATE      06/06/1920
 20.1)     COMPLETION DATE        06/06/1920
 21.1)     BENEFICIAL USE         06/06/1920
 22)       PRIORITY DATE          12/31/1920
 26)       WELL LOG               N
 29.1)     LAND
  45  071  29   S
```

```
                              WYOMING  WATER  RIGHTS                                02/07/74            PAGE   19

 1)        PERMIT                 P5511P
 3)        DIVISION               2
 4)        DISTRICT               CAMPBELL
 5.1)      APPLICANT

                                  CLABAUGH, LESLIE
                                  TECKLA RTE.
 7)        FACILITY               GILLETTE, WY
 8)        USE                    EARL #2
 9.1)      WELL LOCATION          STO
  45  071  28
 10.1)     TYPE WELL              DRIL
 11)       DEPTH WELL                   130.00  FEET
 12)       STATIC WATER                  40.00  FEET
 13)       DIAMETER                       4.00  INCHES
 14)       YIELD                          5.00  GPM
 18)       APPROVAL DATE          05/25/1970
 19.1)     COMMENCEMENT DATE      04/11/1951
 20.1)     COMPLETION DATE        04/13/1951
 21.1)     BENEFICIAL USE         04/13/1951
 22)       PRIORITY DATE          04/13/1951
 26)       WELL LOG               Y
 29.1)     LAND
  45  071  28
```

```
                  WYOMING  WATER  RIGHTS                         02/07/74        PAGE   20

1)       PERMIT                 P5512P
3)       DIVISION               2
4)       DISTRICT               CAMPBELL
5.1)     APPLICANT
                                CLABAUGH, LESLIE
                                TECKLA RTE.
                                GILLETTE, WY
7)       FACILITY               CLABAUGH #1
8)       USE                    DOM
8)       USE                    STK
9.1)     WELL LOCATION
 46  071  33
10.1)    TYPE WELL              DRIL                                                 X
11)      DEPTH WELL                  150.00  FEET
12)      STATIC WATER                 40.00  FEET
13)      DIAMETER                      6.00  INCHES
14)      YIELD                        19.00  GPM
15)      APPROVAL DATE          05/25/1970
19.1)    COMMENCEMENT DATE      06/01/1953
20.1)    COMPLETION DATE        06/09/1953
21.1)    BENEFICIAL USE         11/03/1953
22)      PRIORITY DATE          06/09/1953
26)      WELL LOG               Y
29.1)    LAND
 46  071  33                                                                         SD
```

```
                  WYOMING  WATER  RIGHTS                         02/07/74        PAGE   21

1)       PERMIT                 P5513P
3)       DIVISION               2
4)       DISTRICT               CAMPBELL
5.1)     APPLICANT
                                CLABAUGH, LESLIE
                                TECKLA RTE.
                                GILLETTE, WY
7)       FACILITY               CLABAUGH #2
8)       USE                    STK
9.1)     WELL LOCATION
 47  071  01                                          X
10.1)    TYPE WELL              DRIL
11)      DEPTH WELL                  239.00  FEET
12)      STATIC WATER                 70.00  FEET
13)      DIAMETER                      6.00  INCHES
14)      YIELD                         5.00  GPM
15)      APPROVAL DATE          05/25/1970
19.1)    COMMENCEMENT DATE      12/22/1956
20.1)    COMPLETION DATE        12/31/1956
21.1)    BENEFICIAL USE         12/31/1956
22)      PRIORITY DATE          12/31/1956
26)      WELL LOG               Y
29.1)    LAND
 47  071  01                                          S
```

```
                  WYOMING  WATER  RIGHTS                         02/07/74        PAGE   22

1)       PERMIT                 P5514P
3)       DIVISION               2
4)       DISTRICT               CAMPBELL
5.1)     APPLICANT
                                CLABAUGH, LESLIE
                                TECKLA RTE.
                                GILLETTE, WY
7)       FACILITY               CLABAUGH #3
8)       USE                    STK
9.1)     WELL LOCATION
 47  071  04
10.1)    TYPE WELL              DRIL                                X
11)      DEPTH WELL                  210.00  FEET
12)      STATIC WATER                 60.00  FEET
13)      DIAMETER                      6.00  INCHES
14)      YIELD                         4.00  GPM
15)      APPROVAL DATE          05/25/1970
19.1)    COMMENCEMENT DATE      05/05/1958
20.1)    COMPLETION DATE        05/05/1958
21.1)    BENEFICIAL USE         05/06/1958
22)      PRIORITY DATE          05/05/1958
26)      WELL LOG               Y
29.1)    LAND
 47  071  04                                                        S
```

```
                         WYOMING WATER RIGHTS                                   02/07/74          PAGE   23
 1)       PERMIT                  P5515P
 3)       DIVISION                2
 4)       DISTRICT                CAMPBELL
 5.1)     APPLICANT

                                  CLABAUGH, LESLIE
                                  TECKLA RTE.
                                  GILLETTE, WY
 7)       FACILITY                CLABAUGH #4
 8)       USE                     STK
 9.1)     WELL LOCATION
  49  071  34                                                  X
 10.1)    TYPE WELL               DRIL
 11)      DEPTH WELL                   114.00  FEET
 12)      STATIC WATER                  30.00  FEET
 13)      DIAMETER                       7.00  INCHES
 14)      YIELD                         10.00  GPM
 15)      APPROVAL DATE           05/25/1970
 19.1)    COMMENCEMENT DATE       07/24/1964
 20.1)    COMPLETION DATE         08/22/1964
 21.1)    BENEFICIAL USE          08/30/1964
 22)      PRIORITY DATE           08/28/1964
 26)      WELL LOG                Y
 29.1)    LAND
  49  071  35                                                  S
```

```
                         WYOMING WATER RIGHTS                                   02/07/74          PAGE   24
 1)       PERMIT                  P5516P
 3)       DIVISION                2
 4)       DISTRICT                CAMPBELL
 5.1)     APPLICANT

                                  CLABAUGH, LESLIE
                                  TECKLA RTE.
                                  GILLETTE, WY
 7)       FACILITY                CLABAUGH #5
 8)       USE                     STK
 9.1)     WELL LOCATION
  47  071  03
 10.1)    TYPE WELL               DRIL                                          X
 11)      DEPTH WELL                   120.00  FEET
 12)      STATIC WATER                  55.00  FEET
 13)      DIAMETER                       6.63  INCHES
 14)      YIELD                          5.00  GPM
 15)      APPROVAL DATE           05/25/1970
 19.1)    COMMENCEMENT DATE       07/13/1966
 20.1)    COMPLETION DATE         07/14/1965
 21.1)    BENEFICIAL USE          07/20/1965
 22)      PRIORITY DATE           07/14/1966
 26)      WELL LOG                Y
 29.1)    LAND
  47  071  03                                                                   S
```

```
                         WYOMING WATER RIGHTS                                   02/06/74          PAGE   31a
 1)       CERTIFICATE             C26/323
 2.1)     PERMIT                  P531R
 3)       DIVISION                2
 4)       DISTRICT                10
 5.1)     PROOF                   6545
 6.1)     APPROPRIATOR

                                  JOHN MORTON SHEEP CO.
                                  GILLETTE, WY
 7)       FACILITY                SULLIVAN RES.
 8)       USE                     STK
 8)       USE                     DOM
 9)       SOURCE                  DRY G
                                  BUCK REST CK
 10.1)    TRIBUTARY               HORSE CK
                                  CABALLO CK
 10.2)    TRIBUTARY               BELLE FOURCHE R
 10.3)    TRIBUTARY               CHEYENNE R  SD
 13)      PRIORITY DATE           10/05/1906
 16.1)    OUTLET
  49  071  15
 18.1)    ADJUDICATED AC-FT            7.00  ACRE-FEET                 X
 22.1)    CERT/ORDER RECORD       C4/050
 23)      NOTICES

                                  S - SOURCE INCOMPLETE  ON RECORD
                                  T - TRIBUTARIES INCOMPLETE  ON RECORD
 25)      HEIGHT OF DAM                10.00  FEET
 27.1)    LAND
  48  071  19                                                  P
```

```
                                  WYOMING  WATER  RIGHTS                         02/07/74          PAGE   52

 1)       PERMIT                  P16957P
 3)       DIVISION                2
 4)       DISTRICT                CAMPBELL
 5.1)     APPLICANT
                                  CASSIDY, JAMES M.
                                  BOX 673
                                  GILLETTE, WY  82716
 7)       FACILITY                CASSIDY #1
 8)       USE                     STO
 8)       USE                     DOM
 9.1)     WELL LOCATION
  48  071  23                                        X
 10.1)    TYPE WELL               DRIL
 11)      DEPTH WELL                    75.00  FEET
 12)      STATIC WATER                  20.00  FEET
 13)      DIAMETER                       6.00  INCHES
 14)      YIELD                         15.00  GPM
 15)      TOP MWZ                 UNKNOWN
 16)      BOTTOM MWZ              UNKNOWN
 17)      FIRST WBZ               UNKNOWN
 18)      APPROVAL DATE           12/06/1972
 19.1)    COMMENCEMENT DATE       06/00/1946
 20.1)    COMPLETION DATE         06/00/1946
 21.1)    BENEFICIAL USE          06/00/1946
 22)      PRIORITY DATE           12/31/1946
 26)      WELL LOG                N
 27)      CHEMICAL ANALYSIS       N
 29.1)    LAND
  48  071  25                                        SD


                                  WYOMING  WATER  RIGHTS                         02/07/74          PAGE   53

 1)       PERMIT                  P16958P
 3)       DIVISION                2
 4)       DISTRICT                CAMPBELL
 5.1)     APPLICANT
                                  CASSIDY, JAMES M.
                                  BOX 673
                                  GILLETTE, WY  82716
 7)       FACILITY                CASSIDY #2
 8)       USE                     STO
 9.1)     WELL LOCATION
  48  071  25                                        X
 10.1)    TYPE WELL               DRIL
 11)      DEPTH WELL                   105.00  FEET
 12)      STATIC WATER                  15.00  FEET
 13)      DIAMETER                       6.00  INCHES
 14)      YIELD                          7.00  GPM
 15)      TOP MWZ                       90.00  FEET
 16)      BOTTOM MWZ                   105.00  FEET
 17)      FIRST WBZ               UNKNOWN
 18)      APPROVAL DATE           12/06/1972
 19.1)    COMMENCEMENT DATE       03/00/1962
 20.1)    COMPLETION DATE         03/00/1962
 21.1)    BENEFICIAL USE          03/00/1962
 22)      PRIORITY DATE           03/31/1962
 26)      WELL LOG                Y
 27)      CHEMICAL ANALYSIS       N
 29.1)    LAND
  48  071  25                                        S


                                  WYOMING  WATER  RIGHTS                         02/07/74          PAGE   62

 1)       PERMIT                  P13090P
 3)       DIVISION                2
 4)       DISTRICT                CAMPBELL
 5.1)     APPLICANT
                                  MITCHUM, EILEEN
                                  147 S. SUN DR.
                                  CASPER, WY  82601
 5.2)     APPLICANT
                                  FOLEY, JOE
                                  3625 ALEXANDER
                                  CHEYENNE, WY  82001
 6.1)     AGENT
                                  MITCHUM, EILEEN
                                  147 S. SUN DR.
                                  CASPER, WY  82601
 7)       FACILITY                FOLEY #1
 8)       USE                     STO
 9.1)     WELL LOCATION
  48  071  21          X
 10.1)    TYPE WELL               DRIL
 11)      DEPTH WELL                    60.00  FEET
 12)      STATIC WATER                  30.00  FEET
 13)      DIAMETER                       6.00  INCHES
 14)      YIELD                          2.00  GPM
 15)      TOP MWZ                 UNKNOWN
 16)      BOTTOM MWZ              UNKNOWN
 17)      FIRST WBZ               UNKNOWN
 18)      APPROVAL DATE           01/16/1973
 20.1)    COMPLETION DATE         06/00/1916
 21.1)    BENEFICIAL USE          06/00/1916
 22)      PRIORITY DATE           12/31/1916
 25)      NOTICES
                                  Y - DATE(S) MISSING  (COMMENCEMENT)
 26)      WELL LOG                N
 27)      CHEMICAL ANALYSIS       N
 29.1)    LAND
  48  071  21          S
```

```
                        W Y O M I N G   W A T E R   R I G H T S                02/07/74          PAGE   63

1)        PERMIT                P16047P
3)        DIVISION              2
4)        DISTRICT              CAMPBELL
5.1)      APPLICANT
                                FOLEY, JOE
                                3629 ALEXANDER
                                CHEYENNE, WY  82001
5.2)      APPLICANT
                                MITCHUM, EILEEN
                                144 S. SUN DR.
                                CASPER, WY  82601
6.1)      AGENT
                                MITCHUM, EILEEN
                                144 S. SUN DR.
                                CASPER, WY  82601
7)        FACILITY              FOLEY #2
8)        USE                   STK
9.1)      WELL LOCATION
 49  071  21                     X
10.1)     TYPE WELL             DRIL
11)       DEPTH WELL                 130.00  FEET
12)       STATIC WATER               105.00  FEET
13)       DIAMETER                     4.00  INCHES
14)       YIELD                        2.00  GPM
15)       TOP ZONE              UNKNOWN
16)       BOTTOM ZONE           UNKNOWN
17)       FIRST ZONE            UNKNOWN
18)       APPROVAL DATE         01/15/1973
20.1)     COMPLETION DATE       00/00/1946
21.1)     BENEFICIAL USE        00/00/1946
22)       PRIORITY DATE         12/31/1946
25)       NOTICES
                                9 - DATE(S) MISSING (COMMENCEMENT)
26)       WELL LOG              N
27)       CHEMICAL ANALYSIS     N
29.1)     LAND
 49  071  21                     S
```

```
                        W Y O M I N G   W A T E R   R I G H T S                02/07/74          PAGE  103

1)        PERMIT                P23436P
3)        DIVISION              2
4)        DISTRICT              CAMPBELL
5.1)      APPLICANT
                                DUNLAP, RICHARD D.
                                BOX 716
                                GILLETTE, WY  82716
7)        FACILITY              DUNLAP #2
8)        USE                   STK
9.1)      WELL LOCATION
 46  071  17                       X
10.1)     TYPE WELL             DRIL
11)       DEPTH WELL                 250.00  FEET
12)       STATIC WATER          UNKNOWN
13)       DIAMETER                     6.00  INCHES
14)       YIELD                       25.00  GPM
15)       TOP ZONE              UNKNOWN
16)       BOTTOM ZONE           UNKNOWN
17)       FIRST ZONE            UNKNOWN
18)       APPROVAL DATE         07/25/1973
19.1)     COMMENCEMENT DATE     00/00/1935
20.1)     COMPLETION DATE       00/00/1935
21.1)     BENEFICIAL USE        00/00/1935
22)       PRIORITY DATE         07/26/1973
26)       WELL LOG              N
27)       CHEMICAL ANALYSIS     N
29.1)     LAND
 46  071  17                       S
```

```
                        W Y O M I N G   W A T E R   R I G H T S                02/07/74          PAGE  104

1)        PERMIT                P23437P
3)        DIVISION              2
4)        DISTRICT              CAMPBELL
5.1)      APPLICANT
                                DUNLAP, RICHARD D.
                                BOX 716
                                GILLETTE, WY  82716
7)        FACILITY              DUNLAP #3
8)        USE                   STK
9)        USE                   DOM
9.1)      WELL LOCATION
 46  071  31          X
10.1)     TYPE WELL             DRIL
11)       DEPTH WELL                 250.00  FEET
12)       STATIC WATER          UNKNOWN
13)       DIAMETER                     6.00  INCHES
14)       YIELD                       10.00  GPM
15)       TOP ZONE              UNKNOWN
16)       BOTTOM ZONE           UNKNOWN
17)       FIRST ZONE            UNKNOWN
18)       APPROVAL DATE         07/27/1973
19.1)     COMMENCEMENT DATE     00/00/1935
20.1)     COMPLETION DATE       00/00/1935
21.1)     BENEFICIAL USE        00/00/1935
22)       PRIORITY DATE         07/26/1973
26)       WELL LOG              N
27)       CHEMICAL ANALYSIS     N
29.1)     LAND
 48  071  21          SD
```

```
                         WYOMING  WATER  RIGHTS                     02/07/74        PAGE  105

1)        PERMIT                P23435P
3)        DIVISION              2
4)        DISTRICT              CAMPBELL
5.1)      APPLICANT
                                DUNLAP, RICHARD O.
                                BOX 716
                                GILLETTE, WY  82716
7)        FACILITY              DUNLAP #4
8)        USE                   DOM
8)        USE                   STK
9.1)      WELL LOCATION
 48  071  31              X
10.1)     TYPE WELL             DRIL
11)       DEPTH WELL                 120.00  FEET
12)       STATIC WATER          UNKNOWN
13)       DIAMETER                    6.00  INCHES
14)       YIELD                      25.00  GPM
15)       TOP PERZ              UNKNOWN
16)       BOTTOM PERZ           UNKNOWN
17)       FIRST H2Z             UNKNOWN
18)       APPROVAL DATE         07/25/1973
19.1)     COMMENCEMENT DATE     00/00/1945
20.1)     COMPLETION DATE       00/00/1945
21.1)     BENEFICIAL USE        00/00/1945
22)       PRIORITY DATE         07/26/1973
26)       WELL LOG              N
27)       CHEMICAL ANALYSIS     N
29.1)     LAND
 48  071  31              SD
```

```
                         WYOMING  WATER  RIGHTS                     02/07/74        PAGE  106

1)        PERMIT                P23435P
3)        DIVISION              2
4)        DISTRICT              CAMPBELL
5.1)      APPLICANT
                                DUNLAP, RICHARD O.
                                BOX 716
                                GILLETTE, WY  82716
7)        FACILITY              DUNLAP #5
8)        USE                   STK
9.1)      WELL LOCATION
 48  071  29                                                X
10.1)     TYPE WELL             DRIL
11)       DEPTH WELL                 120.00  FEET
12)       STATIC WATER          UNKNOWN
13)       DIAMETER                    6.00  INCHES
14)       YIELD                      25.00  GPM
15)       TOP PERZ              UNKNOWN
16)       BOTTOM PERZ           UNKNOWN
17)       FIRST H2Z             UNKNOWN
18)       APPROVAL DATE         07/25/1973
19.1)     COMMENCEMENT DATE     00/00/1945
20.1)     COMPLETION DATE       00/00/1945
21.1)     BENEFICIAL USE        00/00/1945
22)       PRIORITY DATE         07/26/1973
26)       WELL LOG              N
27)       CHEMICAL ANALYSIS     N
29.1)     LAND
 48  071  29                                                S
```

```
                         WYOMING  WATER  RIGHTS                     02/07/74        PAGE  107

1)        PERMIT                P23440P
3)        DIVISION              2
4)        DISTRICT              CAMPBELL
5.1)      APPLICANT
                                DUNLAP, RICHARD O.
                                BOX 716
                                GILLETTE, WY  82716
7)        FACILITY              DUNLAP #6
8)        USE                   STK
9.1)      WELL LOCATION
 47  071  06                                      X
10.1)     TYPE WELL             DRIL
11)       DEPTH WELL                  50.00  FEET
12)       STATIC WATER          UNKNOWN
13)       DIAMETER                    6.00  INCHES
14)       YIELD                      25.00  GPM
15)       TOP PERZ              UNKNOWN
16)       BOTTOM PERZ           UNKNOWN
17)       FIRST H2Z             UNKNOWN
18)       APPROVAL DATE         07/25/1973
19.1)     COMMENCEMENT DATE     00/00/1940
20.1)     COMPLETION DATE       00/00/1940
21.1)     BENEFICIAL USE        00/00/1940
22)       PRIORITY DATE         07/26/1973
26)       WELL LOG              N
27)       CHEMICAL ANALYSIS     N
29.1)     LAND
 47  071  06                                      S
```

```
                         W Y O M I N G   W A T E R   R I G H T S                 02/07/74        PAGE  108

1)       PERMIT                  P23441P
3)       DIVISION                2
4)       DISTRICT                CAMPBELL
5.1)     APPLICANT
                                 DUNLAP, RICHARD C.
                                 BOX 714
                                 GILLETTE, WY  82716
7)       FACILITY                DUNLAP #7
8)       USE                     STO
9.1)     WELL LOCATION
 47  071  02                                                       X
10.1)    TYPE WELL               USIL
11)      DEPTH WELL                    120.00  FEET
12)      STATIC WATER            UNKNOWN
13)      DIAMETER                        6.00  INCHES
14)      YIELD                          25.00  GPM
15)      TOP ZONE                UNKNOWN
16)      BOTTOM ZONE             UNKNOWN
17)      FIRST ZONE              UNKNOWN
18)      APPROVAL DATE           07/24/1973
19.1)    COMMENCEMENT DATE       03/30/1940
20.1)    COMPLETION DATE         03/00/1940
21.1)    BENEFICIAL USE          06/00/1940
22)      PRIORITY DATE           07/24/1973
26)      WELL LOG                N
27)      CHEMICAL ANALYSIS       N
29.1)    LAND
 47  071  07                                                       $
```

```
                         W Y O M I N G   W A T E R   R I G H T S                 02/07/74        PAGE  119

1)       PERMIT                  P5497A
3)       DIVISION                2
4)       DISTRICT                10
5.1)     APPLICANT
                                 WYOMING GAME & FISH COMMISSION
                                 CHEYENNE, WY
7)       FACILITY                CABALLO
8)       USE                     FIS
8)       USE                     STO
9)       SOURCE                  CABALLO CR
                                 HORSE CR
10.1)    TRIBUTARY               BELLE FOURCHE R
10.2)    TRIBUTARY               CHEYENNE R  SD
11.1)    OUTLET
 48  071  31                                                  X
12)      HIGH WATER                  126.10  ACRES
13)      TOTAL CAPACITY              807.70  ACRE-FEET
14)      APPROVAL DATE           06/14/1943
19.1)    COMMENCEMENT DATE       10/15/1943
20.1)    COMPLETION DATE         07/15/1948
21)      PRIORITY DATE           04/05/1943
24)      NOTICES

                                 S - SOURCE INCOMPLETE ~~[illegible]~~ ON RECORD
                                 # - COMMENCEMENT FILED IN GOOD STANDING
                                 $ - COMPLETION FILED IN GOOD STANDING
25)      HEIGHT OF DAM                 26.00  FEET
27.2)    LAND
 47  071  06
27.4)    LAND
 48  071  31
```

```
                         W Y O M I N G   W A T E R   R I G H T S                 02/07/74        PAGE  127

1)       PERMIT                  P335
3)       DIVISION                2
4)       DISTRICT                10
5.1)     APPLICANT
                                 DEMAEGT, CYRIEL
                                 GILLETTE, WY
7)       FACILITY                CARMYN
8)       USE                     STO
9)       SOURCE                  HAMMER DR
10.1)    TRIBUTARY               CABALLO CR
                                 HORSE CR
10.2)    TRIBUTARY               BELLE FOURCHE R
10.3)    TRIBUTARY               CHEYENNE R  SD
11.1)    OUTLET
 48  071  22                                                       X
12)      HIGH WATER                    1.80  ACRES
13)      TOTAL CAPACITY                5.60  ACRE-FEET
17)      APPROVAL DATE           10/09/1941
18.1)    COMMENCEMENT DATE       11/10/1941
19.1)    COMPLETION DATE         11/15/1941
20)      PRIORITY DATE           09/25/1941
23)      NOTICES

                                 # - COMMENCEMENT FILED IN GOOD STANDING
                                 $ - COMPLETION FILED IN GOOD STANDING
24)      HEIGHT OF DAM                  9.60  FEET
25.1)    EXPLANATORY             PERMIT CARRIES THIS AS CADALLO CR
26.1)    LAND
 48  071  22
26.2)    LAND
 48  071  27
```

```
                                 W Y O M I N G   W A T E R   R I G H T S                     02/07/74           PAGE  134

1)       PERMIT                 P6[illegible]4S
3)       DIVISION               2
4)       DISTRICT               10
5.1)     APPLICANT
                                FOLEY, P. T.
7)       FACILITY               GILLETTE, WY
8)       USE                    BAXTER
9)       SOURCE                 STK
10.1)    TRIBUTARY              BAXTER DR
                                CABALLO CK
10.2)    TRIBUTARY              HORSE CK
10.3)    TRIBUTARY              BELLE FOURCHE R
11.1)    OUTLET                 CHEYENNE R  SD
 48  071  28
12)      HIGH WATER                                              X
13)      TOTAL CAPACITY              0.67  ACRES
17)      APPROVAL DATE               1.99  ACRE-FEET
18.1)    COMMENCEMENT DATE      11/10/1953
19.1)    COMPLETION DATE        11/10/1953
20)      PRIORITY DATE          12/01/1953
23)      NOTICES                10/13/1953

                                # - COMMENCEMENT FILED IN GOOD STANDING
24)      HEIGHT OF DAM          $ - COMPLETION FILED IN GOOD STANDING
25.1)    EXPLANATORY                 13.90  FEET
26.1)    LAND                   PERMIT CARRIES THIS AS CABALLO CK
 48  071  28
                                                   P
```

```
                                 W Y O M I N G   W A T E R   R I G H T S                     02/07/74           PAGE  153

1)       PERMIT                 P6147S
3)       DIVISION               2
4)       DISTRICT               10
5.1)     APPLICANT
                                CLABAUGH, LESLIE C. & RONNIE A.
                                TECKLA RTE
7)       FACILITY               GILLETTE, WY 82716
8)       USE                    LES
9)       SOURCE                 STK
10.1)    TRIBUTARY              LES CR
                                HORSE CK
10.2)    TRIBUTARY              CABALLO CK
10.3)    TRIBUTARY              BELLE FOURCHE R
11.1)    OUTLET                 CHEYENNE R SD
 47  071  02
12)      HIGH WATER                                                              X
13)      TOTAL CAPACITY              0.81  ACRES
17)      APPROVAL DATE               1.63  ACRE-FEET
18.1)    COMMENCEMENT DATE      03/27/1968
19.1)    COMPLETION DATE        11/25/1968
20)      PRIORITY DATE          12/15/1968
23)      NOTICES                01/26/1968

                                # - COMMENCEMENT FILED IN GOOD STANDING
24)      HEIGHT OF DAM          $ - COMPLETION FILED IN GOOD STANDING
26.1)    LAND                        10.30  FEET
 47  071  02
                                                                                 P
```

```
                                 W Y O M I N G   W A T E R   R I G H T S                     02/07/74           PAGE  161

1)       PERMIT                 P7540S
3)       DIVISION               2
4)       DISTRICT               10
5.1)     APPLICANT
                                DUNLAP, RICHARD J.
                                BOX 716
7)       FACILITY               GILLETTE, WY  82716
8)       USE                    GEORGE
9)       SOURCE                 STK
                                CABALLO CK
10.1)    TRIBUTARY              HORSE CK
10.2)    TRIBUTARY              BELLE FOURCHE R
11.1)    OUTLET                 CHEYENNE R SD
 48  071  31
12)      HIGH WATER                  1.10  ACRES                                              X
13)      TOTAL CAPACITY              2.56  ACRE-FEET
17)      APPROVAL DATE          03/15/1973
18.1)    COMMENCEMENT DATE      02/15/1974
19.1)    COMPLETION DATE        12/31/1974
20)      PRIORITY DATE          07/21/1973
23)      NOTICES

                                A - FORCASTED DATE OF COMMENCEMENT
24)      HEIGHT OF DAM          B - FORCASTED DATE OF COMPLETION
26.1)    LAND                        12.00  FEET
 48  071  31
                                                                                              P
```

```
                    W Y O M I N G   W A T E R   R I G H T S   MASTER RECORD    DATE 02/05/74 PAGE  1616

1)       PERMIT              P76055
3)      DIVISION             2
4)      DISTRICT             10
5.1)    APPLICANT
                             CASSIDY, JAMES H.
                             BOX 673
                             GILLETTE, WY  82716
7)      FACILITY             JIMMY
8)      USE                  STO
9)      SOURCE               TISDALE CK
10.1)   TRIBUTARY            HORSE CK
                             CABALLO CK
10.2)   TRIBUTARY            BELLE FOURCHE R
10.3)   TRIBUTARY            CHEYENNE R SD
11.1)   OUTLET
 49  071  25                                          X
12)      HIGH WATER                   0.20  ACRES
13)      TOTAL CAPACITY               0.92  ACRE-FEET
17)      APPROVAL DATE       12/15/1973
18.1)    COMMENCEMENT DATE   12/17/1973
19.1)    COMPLETION DATE     12/18/1973
20)      PRIORITY DATE       10/16/1973
23)      NOTICES             *S
24)      HEIGHT OF DAM       PIT
26.1)   DAM
 49  071  25                                          P


                    W Y O M I N G   W A T E R   R I G H T S                 02/07/74             PAGE   238

1)       PERMIT              P13249W
3)      DIVISION             2
4)      DISTRICT             CAMPBELL
5.1)    APPLICANT
                             AMAX COAL CO.
                             105 SOUTH MERIDIAN ST.
                             INDIANAPOLIS, IN 46225
6.1)    AGENT
                             JAMES, ROBERT W.
                             AMAX COAL CO.
                             BOX 1050
                             GILLETTE, WY  82716
7)      FACILITY             BELLE AYRE #1
8)      USE                  IND
9.1)    WELL LOCATION
 49  071  36   
11)     ESTIMATED YIELD             50.00  GPM
12)     APPROVAL DATE        03/18/1972
13.1)   COMMENCEMENT DATE    04/15/1972
14.1)   COMPLETION DATE      12/31/1974
15.1)   BENEFICIAL USE       12/31/1974
16)     PRIORITY DATE        02/24/1972
19)     NOTICES
                             * - COMMENCEMENT FILED IN GOOD STANDING
                             # - FORCASTED DATE OF COMPLETION
                             C - FORCASTED DATE OF BENEFICIAL USE
```

TABLE 1-1

Daily Gage Height, in Feet, and Discharge, in Second-Feet, of AMAK SOUTH CABALLO CREEK 12" PARSHALL

Near DUNLAPS FISHING LAKE for the Year Ending September 30, 1974

Drainage Area .... Square Miles. Water-Stage Recorder A35 .... Ratio 1 : 6

Gage Read to .... Once / Twice a Day by ....

File Number { Washington .... District ....

Used rating table dated ....

Gage heights used to half tenths between .... and .... hundredths below and tenths above these limits.

Day	October Gage height	October Discharge	November Gage height	November Discharge	December Gage height	December Discharge	January Gage height	January Discharge	February Gage height	February Discharge	March Gage height	March Discharge	Day	April Gage height	April Discharge	May Gage height	May Discharge	June Gage height	June Discharge	July Gage height	July Discharge	August Gage height	August Discharge	September Gage height	September Discharge	Day
1													1	.12^E	.16	.12	.16	.10	.12	.08	.08	.16	.27	.07	.07	1
2													2	.12^E	.16	.12	.16	.10	.12	.08	.08	.15	.22	.07	.07	2
3													3	.12^E	.16	.12	.16	.10	.12	.08	.06	.13	.13	.07	.07	3
4													4	.12^E	.16	.12	.16	.10	.12	.07	.07	.11	.14			4
5													5	.12^E	.16	.12	.16	.10	.12	.07	.07	.10	.12			5
6													6	.12^E	.16	.12	.16	.10	.12	.07	.07	.06	.06			6
7													7	.12^E	.16	.12	.16	.10	.12	.06	.05	.06	.06			7
8													8	.12^E	.16	.12	.16	.10	.12	.06	.05	.07	.07			8
9													9	.12^E	.16	.11	.14	.10	.12	.06	.05	.07	.07			9
10													10	.12^E	.16	.11	.14	.10	.12	.06	.05	.07	.07			10
11													11	.12^E	.16	.11	.14	.10	.12	.06	.05	.07	.07			11
12													12	.12^E	.16	.11	.14	.09	.10	.06	.05	.07	.07			12
13													13	.12^E	.16	.11	.14	.09	.10	.06	.05	.07	.07			13
14													14	.12^E	.16	.11	.14	.09	.10	.06	.05	.07	.07			14
15													15	.12^E	.16	.11	.14	.09	.10	.06	.05	.07	.07			15
16											.10	.12	16	.12^E	.16	.11	.14	.09	.10	.06	.05	.07	.07			16
17											.10	.12	17	.12^E	.16	.11	.14	.09	.10	.06	.05	.07	.07			17
18											.12	.16	18	.12^E	.16	.17	.27	.09	.10	.07	.07	.07	.07			18
19											.12	.16	19	.09	.10	.12	.16	.09	.10	.08	.08	.07	.07			19
20											.12	.16	20	.16	.25	.12	.16	.09	.10	.20	[illegible]	.07	.07			20
21											.12	.16	21	.14	.20	.11	.14	.09	.10	.20	.35	.07	.07			21
22											.12	.16	22	.13	.18	.11	.14	.08	.08	.20	.35	.07	.07			22
23											.12	.16	23	.13	.18	.11	.14	.08	.08	.20	.35	.07	.07			23
24											.12	.16	24	.13	.18	.11	.14	.08	.08	.20	.35	.07	.07			24
25											.12	.16	25	.13	.18	.11	.14	.08	.08	.20	[illegible]	.07	.05			25
26											.12	.16	26	.13	.18	.12	.16	.08	.08	.19	.31	.06	.05			26
27											.12	.16	27	.13	.18	.12	.16	.08	.08	.19	.31	.06	.05			27
28											.12	.16	28	.13	.18	.12	.16	.08	.08	.19	.31	.06	.05			28
29											.12	.16	29	.12	.16	.12	.16	.08	.08	.17	.27	.07	.07			29
30											.12	.16	30	.12	.16	.11	.14	.08	.08	.17	.27	.07	.07			30
31											.12	.16	31			.11	.14			.17	.27	.07	.07			31
Total												2.48			5.01		4.75		2.77		4.44		2.67			
Mean												.15			.16		.15		.09		.16		.09			
Second-feet per square mile																										
Run-off in depth in inches																										
Run-off in acre-feet												4.91			9.92		9.41		5.48		4.66		5.29			
Maximum												.16			.25		.27		.12		.35		.25			
Minimum												.12			.10		.14		.08		.05		.05			

TABLE 1-2

AMAX SOUTH BELL AYR MINE

Daily Gage Height, in Feet, and Discharge, in Second-Feet, of CABALLO CREEK River / Creek

At / Near THREE CULVERTS NR GILLETTE — 12" PARSHALL — for the Year Ending September 30, 1974

Drainage Area .... Square Miles. Water-Stage Recorder .... Ratio 10" : 12". Gage Read to .... Once / Twice a Day by ....

File Number { Washington .... District ....

Used rating table dated ....

Gage heights used to half tenths between .... and ...., to hundredths below and tenths above these limits.

Day	October Gage height	October Discharge	November Gage height	November Discharge	December Gage height	December Discharge	January Gage height	January Discharge	February Gage height	February Discharge	March Gage height	March Discharge	April Gage height	April Discharge	May Gage height	May Discharge	June Gage height	June Discharge	July Gage height	July Discharge	August Gage height	August Discharge	September Gage height	September Discharge
1													.04	.03	.03	.02	0.0	0		0		0		0
2													.04	.03	.03	.02	0.0	0		0		0		0
3													.04	.03	.02	.01	0.0	0		0		0		0
4													.04	.03	.02	.01	0.0	0		0		0		
5													.04	.03	.02	.01	0.0	0		0		0		
6													.02	.01	.02	.01	0.0	0		0		0		
7													.02	.01	.01	.01	0.0	0		0		0		
8													.02	.01	.00	.00	0.0	0		0		0		
9													.02	.01	.00	.00	0.0	0		0		0		
10													.02	.01	.00	.00	0.0	0		0		0		
11													.02	.01	.00	.00	0.0	0		0		0		
12													.05	.04	.00	.00	0.0	0		0		0		
13													.05	.04	.00	.00	0.0	0		0		0		
14													.05	.04	.00	.00	0.0	0		0		0		
15											.04	.03	.04	.03	.00	.00	0.0	0		0		0		
16											.03	.02	.04	.03	.00	.00	0.0	0		0		0		
17											.02	.01	.04	.03	.00	.00	0.0	0		0		0		
18											.02	.01	.04	.03	.00	.00	0.0	0		0		0		
19											.02	.01	.04	.03	.00	.00	0.0	0		0		0		
20											.04	.03	.06	.05	.00	.00	0.0	0		0		0		
21											.05	.04	.07	.07	.00	.00	0.0	0		0		0		
22											.05	.04	.07	.06	.00	.00	0.0	0		0		0		
23											.06	.05	.06	.05	.00	.00	0.0	0		0		0		
24											.06	.05	.05	.04	.00	.00	0.0	0		0		0		
25											.07	.07	.05	.04	.00	.00	0.0	0		0		0		
26											.06	.05	.04	.03	.00	.00	0.0	0		0		0		
27											.04	.03	.04	.03	.00	.00	0.0	0		0		0		
28											.04	.03	.04	.03	.00	.00	0.0	0		0		0		
29											.04	.03	.04	.03	.00	.00	0.0	0		0		0		
30											.04	.03	.04	.03	.00	.00	0.0	0		0		0		
31											.04	.03			.00	.00				0		0		
Total												0.56		0.94		0.09		0.00		0.00		0.00		
Mean												.03		.03		.003		0.00		0.00		0.00		
[illegible]																								
[illegible]												1.11		1.86		0.18		0.00		0.00		0.00		
[illegible]												.07		.07		.02		0.00		0.00		0.00		
												.01		.01		.01		0.00		0.00		0.00		

TABLE 1-3

AMAX SOUTH BELL AYR MINE

Daily Gage Height, in Feet, and Discharge, in Second-Feet, of CABALLO CREEK River-Creek

Near BELOW BELL AYR MINE 12" PARSHALL for the Year Ending September 30, 1974

Drainage Area .... Square Miles. Water-Stage Recorder A71 Ratio 10" : 12"

Gage Read to .... Once Twice a Day by ....

File Number { Washington .... District ....

Used rating table dated ....

Gage heights used to half tenths between .... and .... hundredths below and tenths above these limits.

Day	October Gage height	October Discharge	November Gage height	November Discharge	December Gage height	December Discharge	January Gage height	January Discharge	February Gage height	February Discharge	March Gage height	March Discharge	April Gage height	April Discharge	May Gage height	May Discharge	June Gage height	June Discharge	July Gage height	July Discharge	August Gage height	August Discharge	September Gage height	September Discharge
1													.13	.18	.13	.18	.11	.14		0		0		0
2													.13	.14	.13	.18	.09	.10		0		0		0
3													.00	.00	.13	.18	.12	.10		0		0		0
4													.00	.00	.13	.18	.11	.14		0		0		
5													.22	.40	.12	.16	.10	.12		0		0		
6													.15	.22	.12	.16	.07	.10		0		0		
7													.20	.35	.11	.14	.08	.08		0		0		
8													.28	.58	.10	.12	.08	.08		0		0		
9													.21	.37	.09	.10	.08	.08		0		0		
10													.20	.35	.10	.12	.05	.04		0		0		
11													.18	.14	.10	.12	.02	.01		0		0		
12													.21	.39	.09	.10	.00	.00		0		0		
13													.22	.40	.10	.12	.00	.00		0		0		
14													.26	.51	.09	.10	.00	.00		0		0		
15											.15	.22	.25	.49	.09	.10	.00	.00		0		0		
16											.15	.22	.17	.27	.08	.08	.00	.00		0		0		
17											.17	.27	.19	.32	.12	.16	.00	.00		0		0		
18											.17	.27	.18	.30	.15	.22	.00	.00		0		0		
19											.19	.32	.14	.20	.17	.27	.00	.00		0		0		
20											.20	.35	.24	.20	.19	.32	.00	.00		0		0		
21											.20	.35	.13	.18	.17	.27	.00	.00		0		0		
22											.20	.35	.20	.35	.14	.20	.00	.00		0		0		
23											.19	.32	.20	.35	.12	.16	.00	.00		0		0		
24											.19	.32	.18	.30	.11	.14	.00	.00		0		0		
25											.19	.32	.15	.22	.10	.12	.00	.00		0		0		
26											.19	.32	.18	.30	.10	.12	.00	.00		0		0		
27											.15	.22	.15	.22	.10	.12	.00	.00		0		0		
28											.15	.22	.15	.22	.11	.14	.00	.00		0		0		
29											.17	.27	.17	.27	.13	.18	.00	.00		0		0		
30											.20	.35	.13	.18	.17	.27	.00	.00		0		0		
31											.20	.35			.17	.27				0		0		
Total												5.04		6.38		5.10		0.99		0.00		0.00		
Mean												.29		.27		.16		0.03		0.00		0.00		
[illegible]																								
[illegible]												9.98		16.59		10.10		1.96		0.00		0.00		
[illegible]												.35		.58		.32		.14		0.00		0.00		
[illegible]												.22		.00		.10		.00		[illegible]		[illegible]		

TABLE 1-4

RING INFILTROMETER TEST NO. 1

AMAX BELLE AYR SOUTH PROPERTY

Location:	SW¼, SW¼, SW¼, Sec. 27, T 48 N, R 71 W
Soil:	Mixture of Terry loamy sand (Rolling phase) and Renohill clay loam. Top 12 inches was dry (< 10% moisture).
Vegetation:	Sagebrush and grass, a few cactus plants. 60% ground cover.
Weather:	Windy, 60°-70°F, Partly Cloudy

Elapsed Time (Min.)	Accumulative Intake Amount (Inches)	Average Intake Rate (In/hr)
0	0	Unknown
5	0.85	10.2
10	1.38	8.28
20	2.58	7.74
30	3.70	7.4
45	5.37	7.16
60	7.07	7.07
90	10.43	6.95
120	13.82	6.91
150	17.28	6.91

TABLE 1-5

RING INFILTROMETER TEST NO. 2

AMAX BELLE AYR SOUTH PROPERTY

Location:	NE¼, SW¼, Sec. 31, T 48 N, R 71 W
Soil:	Mixture of Terry loamy sand and Ulm loam
Vegetation:	Mainly sagebrush and grass, a few cactus plants. 40% - 70% ground cover.
Weather:	Windy, 70°F, Partly cloudy

Elapsed Time (Min.)	Accumulative Intake Amount (Inches)	Average Intake Rate (In/hr)
0	0	Unknown
5	0.78	9.36
10	1.15	6.9
20	1.75	5.25
30	2.28	4.56
45	3.0	4.0
60	3.7	3.7
90	5.08	3.39
120	6.45	3.23
150		
180	9.20	3.07
210	10.6	3.03
240	11.88	2.97

TABLE 1-6

RING INFILTROMETER TEST NO. 3

AMAX BELLE AYR SOUTH PROPERTY

Location: NW¼, NW¼, Sec. 34, T 48 N, R 72 W

Soil: Renohill clay loam

Vegetation: Sagebrush, grasses and cactus. Undisturbed material.

Weather: Clear, calm and 65°-70°

Elapsed Time (Min.)	Accumulative Intake Amount (Inches)	Average Intake Rate (In/hr)
0	0	Unknown
5	0.63	7.5
10	0.9	5.4
20	1.5	4.5
30	2.13	4.26
45	2.98	3.97
60	3.9	3.9
90	5.8	3.87
120	7.7	3.85
150	9.78	3.91
180	11.9	3.97
195	13.0	4.0
210	14.08	4.02

APPENDIX G

Archaeological Survey

Source: Amax Coal Company Environmental Research Studies from a Report by James D. Keyser for the University of Montana Statewide Archaeological Survey

THE UNIVERSITY OF WYOMING
DEPARTMENT OF ANTHROPOLOGY
ARTS AND SCIENCES BUILDING
UNIVERSITY STATION, BOX 3431
LARAMIE, WYOMING 82071

October 29, 1974

U. S. GEOLOGICAL SURVEY
NOV 1 1974
RECEIVED
BILLINGS, MONT.

Mr. A. F. Czarnowsky
Area Mining Supervisor
United States Department of the Interior
Geological Survey
Conservation Division
P.O. Box 2550
Billings, Montana 59103

Dear Mr. Czarnowsky:

The status of Archeological Surveys you inquired about are as follows:

Amax Coal Company - Completed, survey done by archeologists from Montana. I accept their recommendations.

Wyodak Resources Development Corporation - No survey has been done.

Sun Oil Company - Survey nearly completed. Recommendations for site excavations made contingent on mining of certain areas.

Carter Oil Company - Literature surveys made. Will eventually have to do an on-the-ground survey.

Peabody Coal Company - Completed.

Atlantic Richfield Company - Completed.

Kerr-McGee Coal Corporation - Completed. Survey done by their archeologist. I accept their recommendations but in the future have decided not to use company archeologists.

I hope this is what you need.

Sincerely,

George Frison

George C. Frison, Head
Department of Anthropology

GCF:lf

AN ARCHAEOLOGICAL EXAMINATION OF AMAX COAL COMPANY LANDS IN CAMPBELL COUNTY, WYOMING

By

James D. Keyser

for the

University of Montana
Statewide Archaeological Survey

F. W. Sharrock, Director

INTRODUCTION AND ACKNOWLEDGMENTS

In August, 1973, AMAX Coal Company of Indianapolis, Indiana, and the University of Montana Statewide Archaeological Survey contracted through the University of Montana Foundation, to undertake an archaeological reconnaissance survey of lands that would be damaged by proposed strip mining of coal.

Although these lands were located in Campbell County, Wyoming, AMAX contracted with the University of Montana because a previous survey in that area had been done by the University Statewide Archaeological Survey for Ayrshire Coal Company (which has since been incorporated into AMAX). This prior survey was done in August of 1971, and included land which is now the site of the AMAX Belle Ayr Mine and Processing Plant. Permission to conduct the survey was obtained from George Frison, State Archaeologist, and head of the Department of Anthropology at the University of Wyoming. It was agreed that Wyoming would receive copies of all data concerning the survey.

Under the stipulations of the contract, all remains of archaeological, paleontological, and historical materials were to be located and evaluated by the survey crew and then recommendations would be made as to whether any of the materials deserved protection or further examination.

In late August, a two-man field crew consisting of James D. Keyser, a graduate student at the University of Montana, and Ralph E. Atchley, an undergraduate at the same university, conducted a reconnaissance

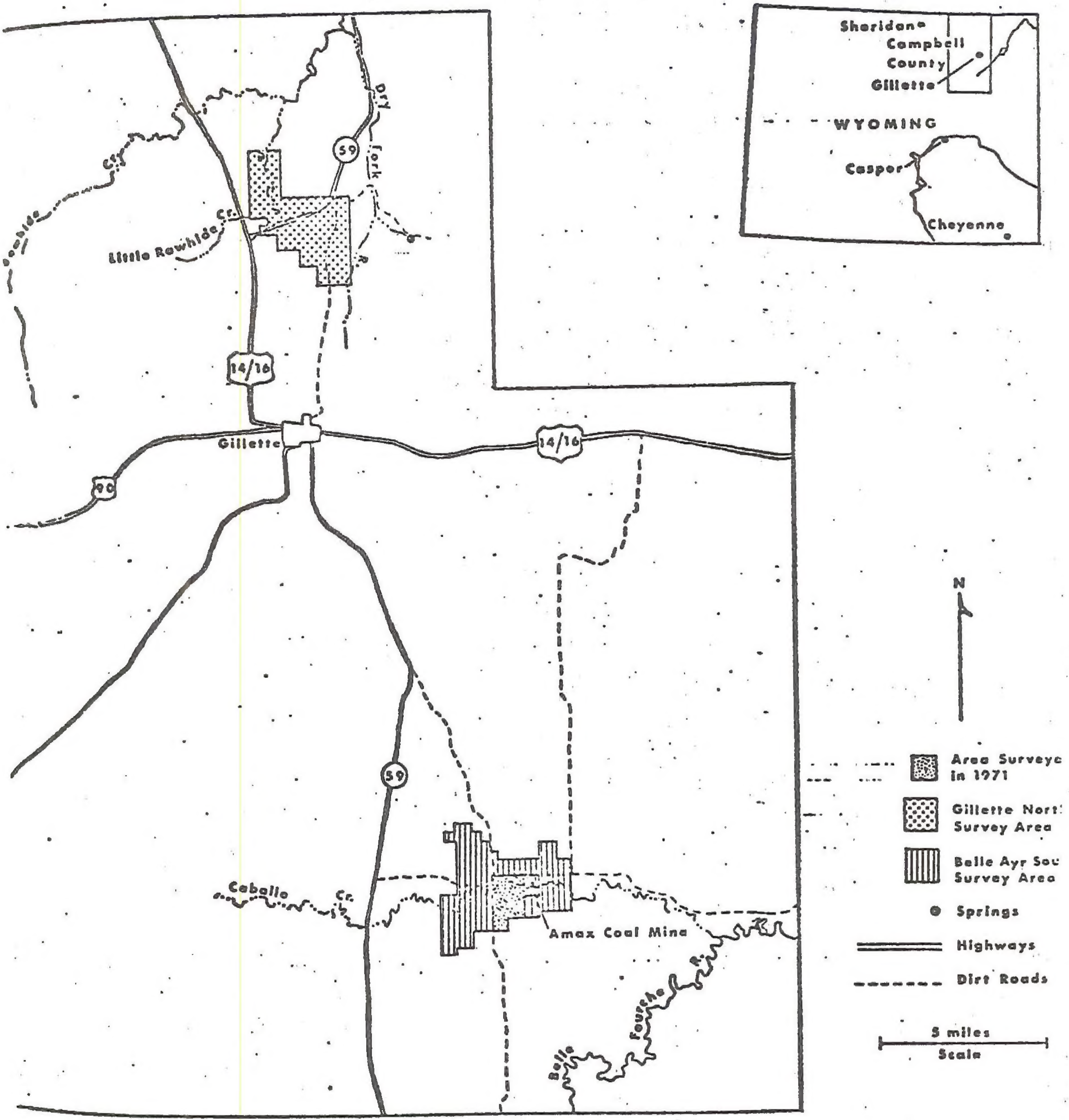

Sheridan
Campbell County
Gillette
WYOMING
Casper
Cheyenne
Rawhide Cr.
Little Rewhide Cr.
Dry Fork R.
59
14/16
Gillette
90
14/16
59
Caballo Cr.
Amax Coal Mine
Belle Fourche R.
N
Area Surveye
in 1971
Gillette Nort
Survey Area
Belle Ayr Sou
Survey Area
Springs
Highways
Dirt Roads
5 miles
Scale

Fig. 1. Map of Gillette area showing areas examined for archaeological remains.

survey of sites in the area. Dr. Floyd Sharrock, professor of Anthropology at the University of Montana, served as project director. All sites discovered were recorded using University of Montana Statewide Archaeological Survey forms, copies of which have been filed at the University of Montana and sent to both the University of Wyoming and the Wyoming Archaeological Society. The Survey was executed by walking all of the designated areas, carefully checking for any surface indications of archaeological, paleontological or historical sites. Occasionally, appropriate locations were checked for subsurface remains by using very limited test excavations.

8,720 acres, in two approximately equal-sized plots, made up the survey area. These two plots are both located entirely within Campbell County in the vicinity of Gillette, Wyoming. A few select locations bordering AMAX property were also examined by the survey crew when it seemed probable that information could be obtained that related to the aboriginal occupation of the survey area. Only three small areas were inspected with this in mind, and one--a large spring just off the northeast corner of the "Gillette North" area--provided important data. It will be discussed later in the report.

The two plots of land, one north of Gillette and the other south of Gillette immediately adjacent to the Belle Ayr Mine, will be referred to as "Gillette North" and "Belle Ayr South", respectively. See Figure 1 for the location of these two plots.

Specifically, "Gillette North" included the following sections (or parts thereof), all located within Township 51 North, Range 72 West:

All of Sections 16, 21, 26, 27 and 35;
The south ½ of Sections 22 and 23;
The northeast ¼ of Section 34; and
The northeast ¼, east ½ of the southeast ¼, and the southeast ¼ of the northwest ¼ of Section 28.

These equal a total of 4,280 acres.

"Belle Ayr South" included the following sections (or parts thereof) located within Township 47 North, Range 71 West:

All of Section 5;
The northwest ¼ of Section 4;
The north ½ of the northeast ¼ of Section 3; and
The north ½ of the northwest ¼ of Section 8.

and the following sections (or parts thereof), located in Township 48 North, Range 71 West:

All of Section 35;
The southeast ¼, and the southeast ¼ of the southwest ¼ of Section 20;
The southwest ¼ of the southwest ¼ of Section 21;
The south ½ and the northwest ¼ of Section 26;
The south ½ of Section 27;
The south ½, northwest ¼ and the southwest ¼ of the northeast ¼ of Section 28;
The east ½ of Section 29;
The south ½ and the northeast ¼ of Section 32;
The west ½ of Section 33; and
The southeast ¼ of Section 34.

These equal a total of 4,440 acres. Portions of Sections 33 and 34 in Township 48 North, and Sections 3 and 4 in Township 47 North, surrounded by our survey area, make up the area surveyed in 1971.

Throughout the survey, we found the AMAX employees to be extremely cooperative in helping us locate our survey boundaries and also in providing us with maps of the area and specialized supplies unavailable elsewhere. In this respect, we wish to extend our sincere thanks to Robert James, Superintendent of the Belle Ayr Mine; Pete Larson, Mine Engineer; Bruce Taylor, AMAX Exploratory Geologist; and Fritz Rottluff, employee of Meadowlark Farms--an AMAX affiliate. We would also like to thank George Frison and Louis Steege, head of the Wyoming Archaeological Society, who were very helpful in assigning site numbers and granting permission to do this survey. James Peterson and Robert Fields, professors of Geology at the University of Montana, identified the stones and fossils found on the survey.

GENERAL SETTING

This area of Wyoming, part of the Powder River basin, is arid, made up of broken butte-and-ridge topography that surrounds large gently rolling basins that are thousands of acres in extent. The buttes and ridges are composed of red baked shale and clinkers which have been metamorphozed by the heat from coal beds that burned thousands of years ago. In areas where this metamorphization has not occurred, the sediments have stayed in their original state and consist of laminated clays, shales, and sandstones which overlay thick beds of coal. These strata--the Fort Union and Wasatch Formations--are of Tertiary age (Brown 1958; Mapel 1958).

Many of the higher buttes and ridges have scattered ponderosa pine growing on them, but unfortunately no major areas of broken topography were included within either of our survey areas. Instead, the two areas we examined consisted mainly of portions of two large basins of gently rolling terrain with occasional low, bare buttes on the peripheries. Each of the areas has at least one major drainage running through it, which even in the dryest part of a dry year had potable water. In the "Gillette North" area, the drainages were supplemented by two good springs.

Rainfall in this area averages 14 inches per year. This has combined with other factors to produce a humid continental climate with the dominant vegetation being sagebrush (Artemesia tridentata), various prairie bunchgrasses, and prickly pear cactus (Opuntia polyacantha). Other less common plants grow in restricted areas.

The fauna of the area is dominated by large herds of ungulates including--prehistorically--bison (Bison bison), antelope (Antilocapra americana), and mule deer (Odocoileus hemionus) and complemented by whitetail jackrabbits (Lepus townsendi), desert cottontails (Sylvilagus auduboni) and sage grouse (Centrodercus urophasianus). Other, smaller mammals, reptiles and birds are found throughout the area in limited numbers. From present indications, it seems that there would be abundant faunal resources in the area at least in some years--resources which would not be difficult to exploit in a prehistoric situation.

In summary, it would seem that from the viewpoint of potential for prehistoric occupation, the only requirement missing from this area is good sheltered campsites, and in general, this is reflected by the type of campsites found--small transient camps, rather than large semi-permanent ones.

ABORIGINAL OCCUPATION

Gillette North

As previously stated, the Gillette North area is a gently rolling flatland with low rugged buttes only at the north edge, just off of our survey area (Fig. 2). It is drained by two major drainages that are separated by a long low ridge in the east half of the area. These

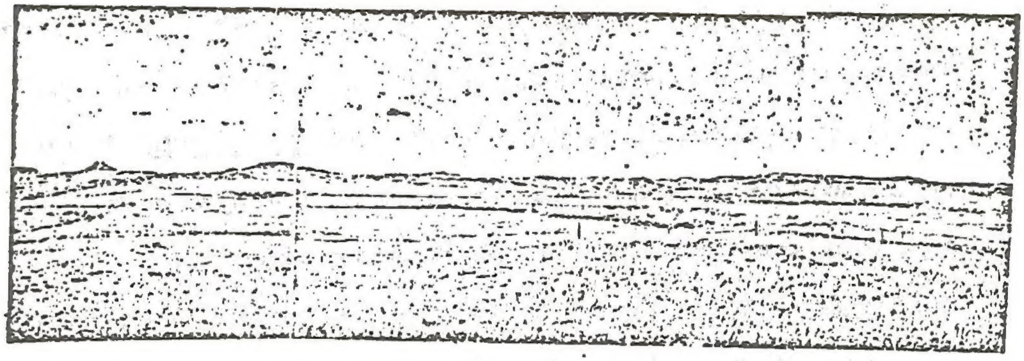


Fig. 3. Composite photograph of Gillette North area. Little Rawhide Creek is in center photo. Note buttes on skyline. Site 48CA315 located on flat to left of cut bank in center photo.

are Little Rawhide Creek which flows north through Sections 21 and 16 and the Dry Fork of the Little Powder River which flows north along the east boundaries of Sections 35 and 26. Springs provide permanent water for both of these streams in their lower reaches, but long stretches of both drainages upstream from the springs flow only intermittently. There are pools of stagnant water in Little Rawhide Creek upstream from the spring, indicating that it may contain running water in wetter seasons.

All of the sites located in Gillette North that were definitely aboriginal were directly related to water. Six sites were located along Little Rawhide Creek, two along the Dry Fork of the Little Powder River and one at the spring in Section 30 that feeds the Dry Fork of the Little Powder River.

The six sites on Little Rawhide Creek will be discussed together as a complex because of their similarity in appearance and their proximity to one another. These are sites 48CA308 through 48CA312 and 48CA315.

All of these sites are situated away from the lowest creek bottoms, either at the rear of the floodplain or on the low ridges that flank the floodplain (Figs. 2,3,4). Some sites occupied both the ridges and the floodplain (e.g. 48CA310), but no sites were found on the floodplain immediately adjacent to the creek. All sites are scattered surface concentrations of lithic material including flake debitage and broken and complete tools. Stone types represented in the lithic debris include local baked shale and petrified wood, and agate, chert, and quartzite from unknown sources. At none of the sites was there any indication of depth of deposits or any type of structures.

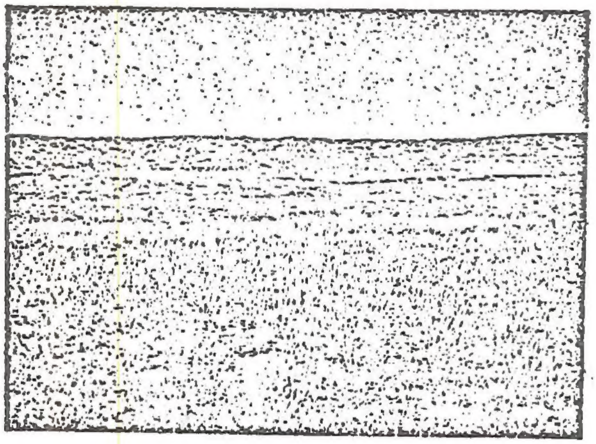


Fig. 4. Site concentration area on Little Rawhide Creek. Site 48CA309 located on ridge behind lone tree at left of photo; site 48CA311 just right of road in center photo; and site 48CA310 on low rise behind creek (dark area) at right center of photo.

Of all the tools found at these sites, projectile points are the only ones that provide any basis for a relative chronology of the periods of occupation. Although there were projectile points at only two of the six sites, the styles indicate a time span of approximately the last 3,000 years. And it seems reasonable to assume that all six sites fall somewhere in that time span.

The oldest projectile point style is represented by the basal portion of either a McKean or a Duncan point (Fig. 5). In shape and size, this point resembles points listed as McKean variants (Mulloy 1954:446) and points listed as Duncan points which were originally named McKean stemmed (Wheeler 1954:7-12). Since these points often occur together in the same level in sites (Wheeler 1954:9), for dating purposes it makes little difference which type it is. In this area, the McKean tradition, including Duncan and Hanna points, has been assigned to the Middle Period and dates prior to 3,000 B.P. (Bentzen 1962; Mulloy 1952, 1954, and 1958; Wheeler 1954).

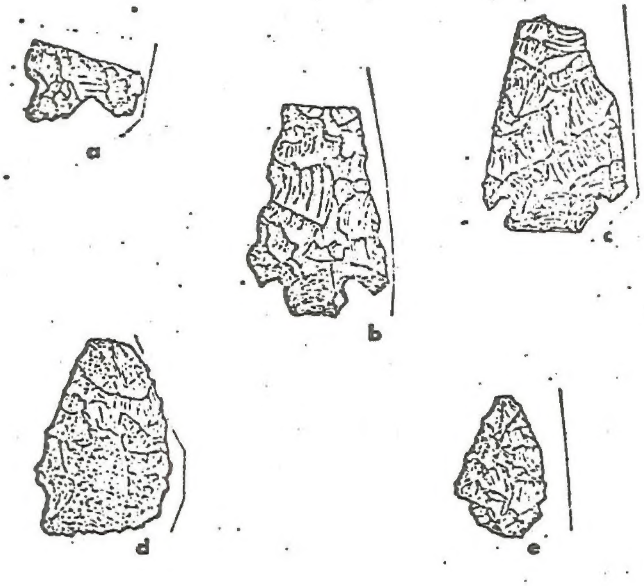


Fig. 5. Projectile points found in Gillette North area. a, McKean point, 48CA315; b, 48CA310; c, 48CA315; d, 48CA316; and e, 48CA315.

5

The next oldest projectile point style, a large corner-notched projectile point, is one that, according to Husted (1968), replaced the McKean tradition in northern Wyoming. We recovered two specimens (Fig. 3). In the relative chronology for the Northwestern Plains, this type of point has been placed in the late Middle Period and shown to be later than the McKean complex but earlier than the small plains side-notched point complex which characterizes Mulloy's (1958) Late Prehistoric Period. Such corner-notched points have been recovered at several sites in the Northwestern Plains, in stratigraphic relationships that confirm this chronology (Frison 1962; Mulloy 1952).

The Late Prehistoric Period, dating from ca. 1 A.D. to 1850 A.D., is represented by two specimens from site 48CA315 (Fig. 5). These are both small side-notched projectile points quite characteristic of this period. Many varieties of side-notched points have been named in different areas of the Northwestern Plains, but in most instances, this has been premature typology. Suffice it here to say that the small side-notched points are the latest stone projectile points used on the Northwestern Plains.

Other tools found at these sites include complete and fragmentary scrapers and blades (Fig. 6). Although none of these are diagnostic for a time period, they do indicate that general camp chores were being done here and this suggests that small bands of both men and women were utilizing the area.

The sparse nature of the remains and the lack of subsurface material indicates that these sites probably were small transient campsites, used repeatedly by bands exploiting the abundant game in the area. Their location near water, but not immediately adjacent to it, is probably explained by a combination of factors, one of the main ones being swarms of insects, a problem that plagued us while we worked in

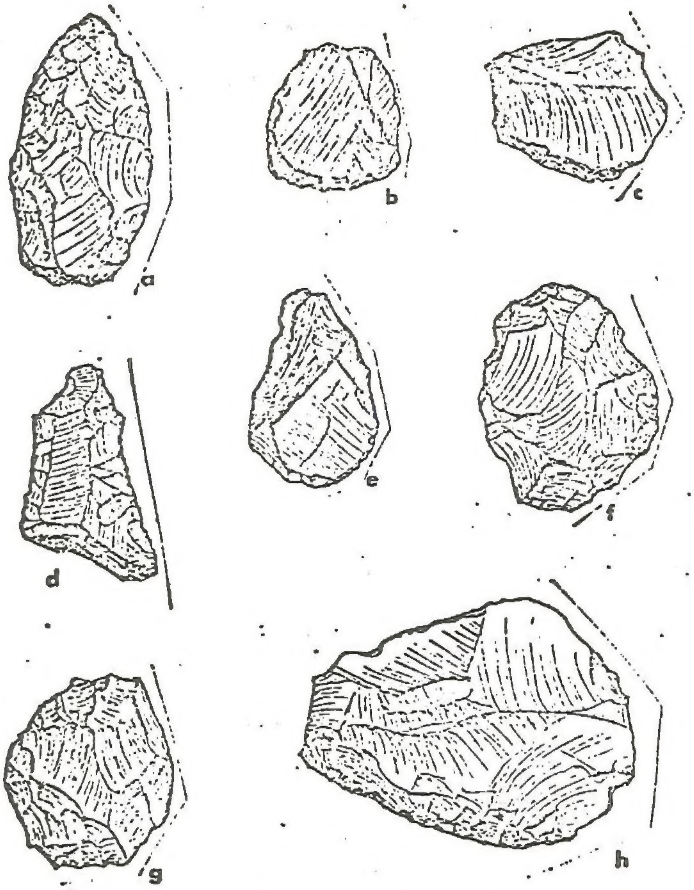


Fig. 6. Tools found at sites in Gillette North area. a-d, scrapers, 48CA315; e, scraper, 48CA309; f,g, scrapers, 48CA316; h, blade, 48CA310.

this area. In the creek bottoms, mosquitoes, horseflies, wasps and other insects swarm in large numbers, but away from the creek and on top of the low ridges the slight breeze and distance from the creek reduces the insect concentration to almost nothing. In view of this, it is a common-sense solution to locate a camp away from the insects, especially when it can be done so easily—and obviously.

The other three aboriginal sites in this area were located along the Dry Fork of the Little Powder River and at the large spring that drains into it. The two sites along the creek were so small that they may have been the result of one person, although the presence of one fragmentary scraper at site 48CA305 would suggest that possibly small groups were occupying this area much like the occupation that occurred along Little Rawhide

Creek, only much more limited in extent. At both of these sites there were a few scattered flakes.

The third site, 48CA316, near the large spring, is a stone circle site with scattered lithic debris. Here there are several complete stone circles and the remains of several partial ones. Possibly these partial circles are ones which have had stones removed to construct the complete circles, although this cannot be ascertained positively. Scattered among these circles and all along the ridge on which they are located are many flakes of quartzite, chert, agate, baked shale and petrified wood--the same types of material that were found at the other sites in this area.

The stone circles average 15 feet in diameter and are made of between 80 and 100 pieces of clinker. This stone outcrops in several places on the ridge. The only deposition on the ridge is a slight accumulation of aeolian soil around the individual stones in the stone circles, but this is not surprising on the sparsely vegetated ridge top.

Stone circles such as these are a common phenomena on the Northwestern Plains. Malouf notes that several different phenomena could produce a circular stone structure, and he suggests that the term tipi ring be restricted to those structures that seem to have been associated with conical skin-covered dwellings (Malouf 1961:388). Kehoe (1958) in a study of stone circles like these, that were located on the Blackfoot Indian Reservation in Montana, concluded that they were the stones used to weight the covers of tipis.

A number of factors--the construction and the location of the circles at 48CA316, and the presence of artifacts near them--suggest that these structures are tipi rings.

Tools found at this site were several blade fragments, scrapers, and one brown quartzite projectile point (Fig. 5d). This corner-notched point is large and crudely made. It definitely is not a plains side-notched point, and because of its size and shape, it seems to best fit typologically with the corner-notched specimens of the late Middle Period. Again, the scrapers and blades indicate that this was probably a campsite utilized much in the same manner as those on Little Rawhide Creek.

One other site in North Gillette deserves mention here, although it probably is not an aboriginal site. Site 48CA307 consists of a small cave near a homestead located in Section 27 (Figs. 7,8). In the cave, which is a 4-foot diameter tunnel eroded into a sandstone outcrop, we found large pieces of charcoal scattered all through a layer of fine aeolian sand, 8 to 12 inches deep. In troweling to test the deposit, we discovered more charcoal and three flakes of glass. No fire hearth was apparent and no stratigraphy was evident in the shallow deposit. Some of the charred wood had not been completely burned and looked like pieces of planed board. Near the cave mouth were several rusted tin cans.

Since the cave was within 200 yards of the homestead and so many historic artifacts were found in or near the cave, it seems likely that it had been used by the occupants of the homestead, either as a play area or dump, as other areas of the sandstone ridge behind the homestead buildings had.

Fig. 7. View of sandstone outcrop containing small cave at 48CA307.

Fig. 8. Closeup of cave at 48CA307.

In summary, it is likely that all nine sites in this area were used as short-term campsites serving as base camps for bands of hunters and gatherers who were exploiting the resources in the area. This occupation seems to have been repeated, at least at some sites, from the Middle Period through the Late Prehistoric Period. The presence of tipi rings at site 48CA316 may indicate that this was a more permanent campsite, but the presence of rings may indicate nothing more than the availability of stone here--stone which was not readily available at the sites on Little Rawhide Creek.

Belle Ayr South

Belle Ayr South was also a relatively flat area, broken only by one small high butte in the northwest corner, and low broken ridges along Caballo Creek on the east edge of the survey area (Fig. 9). Although this area was somewhat more rugged than Gillette North, it had nothing comparable to the pine-covered ridges located a few miles to the east of both areas. Caballo Creek is the only major stream that drains the area. It divides the area approximately in half, flowing from west to east. Several miles east of the survey area it flows into the Belle Fourche River. Although Caballo Creek is an intermittent stream, it has large pools of water which would be potable, especially before the introduction of cattle and sheep into the area. No springs were located in Belle Ayr South.

The aboriginal sites in Belle Ayr South exhibited much the same pattern as those in Gillette North, with the exception of 48CA317, a site located on the flanks of the butte in Section 29. Ten sites were found in the Belle Ayr South area, nine of which were located along Caballo Creek in the western portion of the survey area (Figs. 9,10). Although these sites vary more than the complex of sites along Little Rawhide Creek in North Gillette, they exhibit enough similarities that I will discuss them as a complex also.

Like the sites in Gillette North, the sites along Caballo Creek were located on the floodplain and on the low ridges that flank the creek. In the case of Caballo Creek, the floodplain is much wider so sites on the ridges are further from the creek than sites in Gillette

North. But this does not detract, I think, from the hypothesis that water was a major factor in site location in both of these areas. All sites except 48CA321 were located by surface concentrations of lithic material--local baked shale and petrified wood, and quartzite, chert, agate and obsidian from unknown sources. With the exception of the few obsidian flakes, these are the same types of material that were found in Gillette North. None of the sites along Caballo Creek evidenced any deposition, even though two were tested in a limited manner. The only structure at any of these sites was a stone circle at 48CA321.

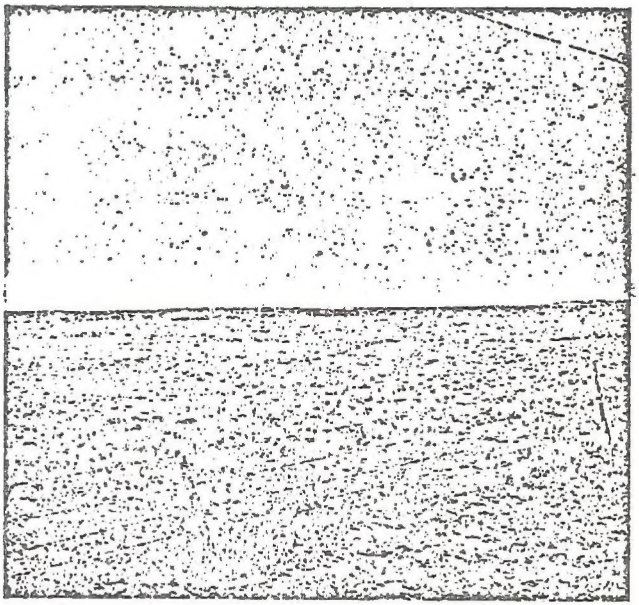


Fig. 10. Photograph looking southwest across Caballo Creek. Site 48CA320 to right and in front of cut bank in center photo. Site 48CA324 located across Caballo Creek to left of cut bank.

Tools and projectile points found at these sites indicate occupation similar to that which occurred on Little Rawhide Creek, in Gillette North. Stylistically, the seven projectile points found (Fig. 11) fit in the Late Prehistoric Period, although minor differences in styles may indicate that they span almost the entire period. The styles range from crudely made, small corner-notched points to the typical plains side-notched points. In between are variations of form and workmanship.

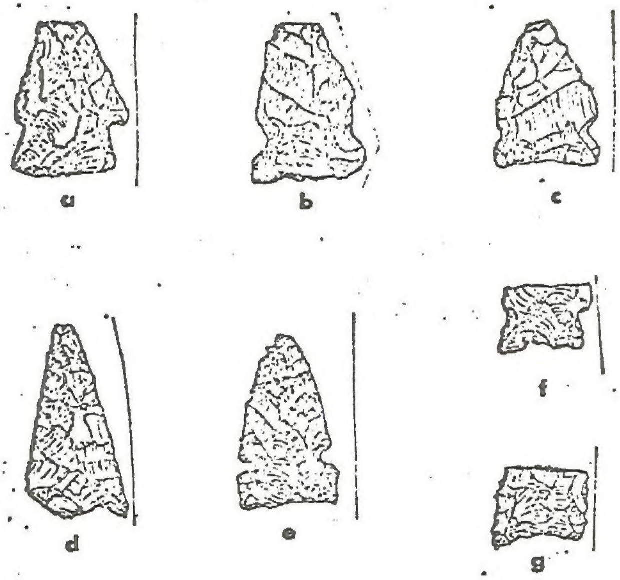


Fig. 11. Projectile points found in Belle Ayr South area. a-c, f, 48CA320; d,e, random finds; g, 48CA323.

I believe that most point typologies for the Northwestern Plains are premature, having been constructed from too little data. This makes a definite statement concerning the relative ages of these different styles almost impossible. But as a general rule, the cruder, thicker corner-notched variants are earlier, and the more delicately made, thinner side-notched points are later. Using this as a guideline, points a, b, c and d in Figure 11, which exhibit some characteristics of both corner-notched dart points and side-notched arrow points, may be older than points e, f and g in the same figure. But this is only tentative; a good typology has yet to be formulated from stratified sites in the area.

The important consideration concerning these projectile points is not their minor variations, but that they indicate that this area was occupied during the Late Prehistoric Period. No evidence was found that suggests any earlier occupation.

Other tools found at these sites make up a varied tool kit which would have been used in the performance of general camp chores. These tools are scrapers, blades, and a broken awl (Fig. 12). Some of the tools were apparently multi-purpose, or they were reused after the original tool first broke. This is best evidenced by the awl (Fig. 12a) which has a scraper edge worked onto its base. This type of a tool assemblage suggests that these sites served as base camps for small hunting bands.

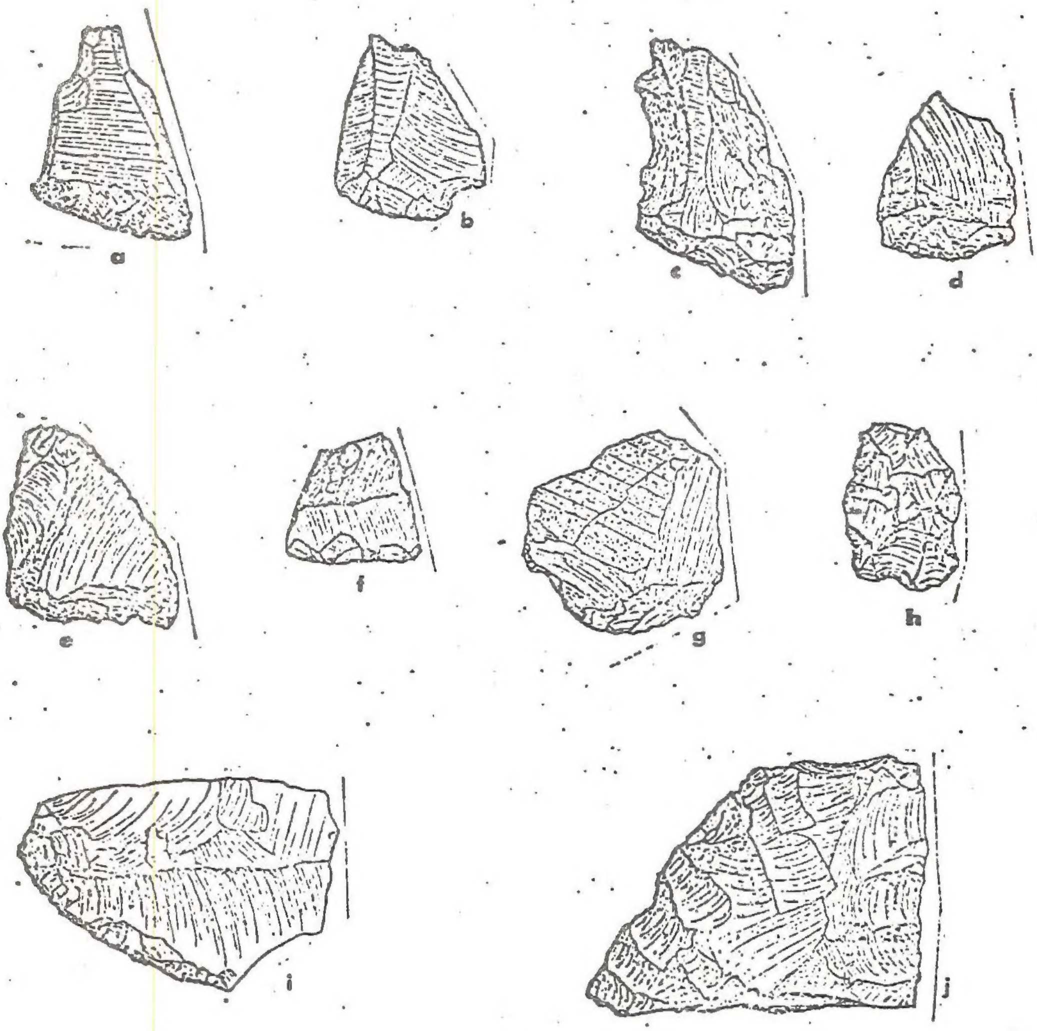


Fig. 12. Tools found at sites in Belle Ayr South area. a, drill/scraper, 48CA320; b, scraper, 48CA319; c, scraper, 48CA326; d,e, scrapers, 48CA324; f, scraper, 48CA320; g, scraper, 48CA318; h, blade (possibly a crude projectile point), 48CA326; i, blade, 48CA320; j, blade, 48CA317.

The one structure found in this area is the stone circle at site 48CA321 (Figs. 13,14). This site is located approximately 400 yards south of Caballo Creek, just up a wide, dry tributary valley. The ring is probably a tipi ring--the stones that were left after having been used to weight down the inner lining or outer covering of a tipi. Eighteen sandstone slabs make up the oval, 14-foot diameter ring, and 14 smaller pieces of sandstone form a smaller structure (Figs. 13,15), 30 inches in diameter, located just southeast of the center of the ring. The position and construction of this smaller interior feature indicate that it may have been a fire hearth. Several of the stones in it are cracked, probably from the heat of the fire, although it is difficult to judge this with sandstone. A large break in the ring on the northeast side may have served as an entryway.

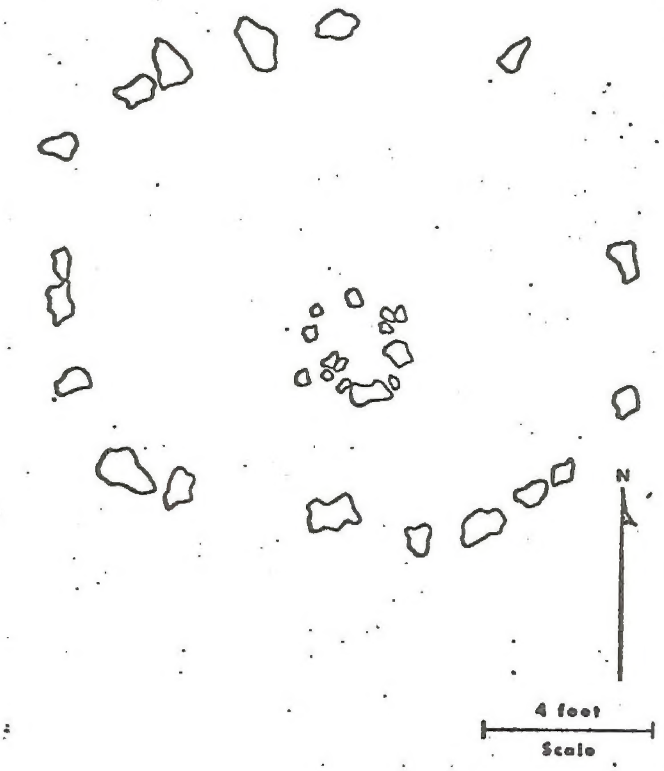


Fig. 13. Plan map of tipi ring at 48CA321. Note smaller circular hearth and opening to northeast.

The sandstone slabs used to construct the ring and hearth could have come from any of several sandstone outcrops located on the ridges to the east and west of the ring. The closest outcrop is less than 100 yards east of the ring.

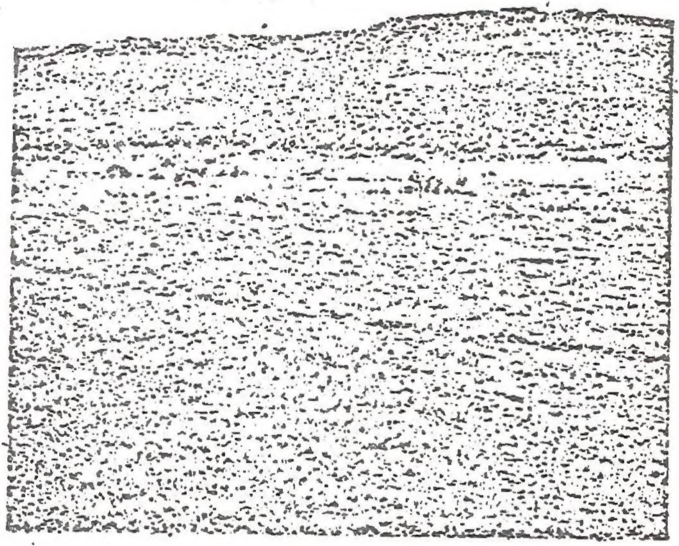


Fig. 14. View looking southwest at tipi ring, made of flat sandstone slabs.

Absolutely no deposition has occurred around any of the stones in the ring. This could be the result of either of two equally plausible factors. The ring may be very recent, or the slight slope on which the ring sites could have facilitated runoff which inhibited deposition. Kehoe has attempted to place tipi rings in a relative chronology according to their size and the amount of deposition around them. But he admits that this does not work well with individual rings (1958:863). So this ring, since it has no associated lithic material, remains undated.

It is possible that the stones in the ring at 48CA321 were used as coverweights for a structure that was not a dwelling, but rather a special function structure, possibly related to sites 48CA322 or 48CA323 which are just north of the ring on the edge of Caballo Creek. The

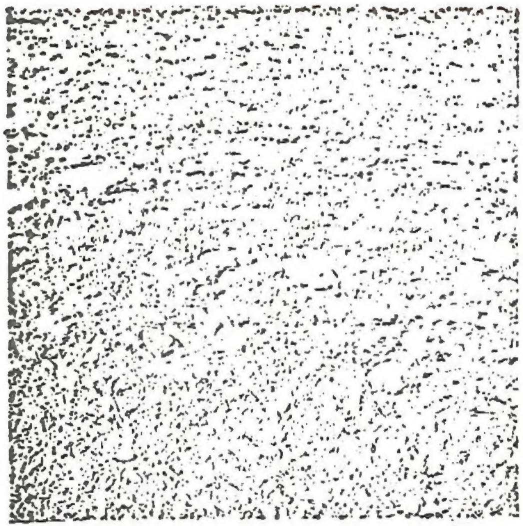


Fig. 15. View of small oval firehearth within tipi ring at 48CA321. Edge of ring in background.

possibility of proving this is remote. I think a more reasonable explanation is that this was a habitation structure, possibly built by just one or two persons as a short-term shelter. Its location--away from the creek and up the tributary valley--and the lack of associated artifacts, suggest that it was a short-term occupation in which the builder was attempting to take advantage of natural shelter and concealment. This site and sites 48CA305 and 48CA306 are the only sites which suggest exclusive use of the area by single hunters or few hunters.

Site 48CA317 was located on the flanks of a butte in the northwest corner of the Belle Ayr South area. Here lithic material, including several blade fragments (Fig. 12), was found scattered on the slopes below the butte. Nothing was found on the butte top, but this is bare sandstone and there is evidence of much modern disturbance. Possibly anything that may have been here has been picked up. The quantity of material here and the area it was scattered over suggest that this site was used more than once. There is no direct evidence to confirm or refute this.

This butte is the highest point in the Belle Ayr South area and from it one can see for several miles in any direction. To the northeast of the butte, approximately 500 yards, there is a dry playa lake. Several flakes were found near this. Although this may have served as a water source, it could have been used only during wet periods and even then for only short periods of time.

The location of this site, away from Caballo Creek, suggests that the site is the result of a special attribute of the area. Since the butte top would serve as a good observation point for the surrounding basin, it seems likely that bands camped here to use it as an observation post, possibly in order to spot herds of game animals.

At present, site 48CA317 is somewhat enigmatic. No other sites classified as observation posts were found, although there were other buttes on which they could have been located, and presumably the need for such sites did exist. A distinct possibility is that other sites of this nature do exist, but on buttes off the examined area. If more sites like this are found in nearby areas, they might help clarify the function of site 48CA317.

Two of the previously discussed projectile points were classed as random finds (Fig. 11 d,e). Both were found away from the creek and had no other evidence of artifacts near them. These are probably points which were lost by hunters.

In conclusion, the pattern of occupation of Belle Ayr South was much like that of Gillette North. Small bands were utilizing the area, camping predominantly along streams and exploiting the rest of the area for game.

GENERAL CONCLUSIONS

Due to the limited area covered by this survey, our data are far from complete concerning the aboriginal usage of the Powder River Basin. And to attempt to fit our data into the overall picture of the prehistoric occupation of this area is even more difficult because there is so little known about the archaeology of the Powder River Basin. With this in mind, I will attempt a general outline of prehistoric life in this area.

For at least the last 3,000 years, the Indians in the Powder River Basin lived primarily on a big game hunting economy. Many buffalo kill sites dating from the Middle Prehistoric and Late Prehistoric periods are scattered throughout the area. Antelope and deer were also hunted. The major occupation sites known in the area occur along the major river drainages. Of these, the McKean site to the east, on the Belle Fourche River is probably the best known. Occupation along the other rivers in the area, the Powder, Tongue and Little Powder rivers, was probably also extensive.

The sites in the small basins near Gillette are not major campsites. Rather they are small transient campsites used by small bands exploiting the interior basin areas away from the major drainages. If occupation along the major rivers occurred primarily in the fall and winter in conjunction with communal bison hunts, the occupation in the Gillette area probably represents spring and summer usage, when the small bands occupied the area for short periods while hunting the large game animals that had scattered over their summer range. Specific tribes occupying this area are not agreed upon. Different authors place the Cheyenne, Shoshoni and Crow in this area at different times, and other groups undoubtedly also used the Powder River Basin. Apparently they all used the Gillette area in much the same manner.

RECOMMENDATIONS

Due to the small size of these sites and the absence of deposition at any of them, no archaeological site in either Gillette North or Belle Ayr South warrants preservation measures or excavation. Site 48CA316, located off of AMAX property, should be tested.

HISTORIC SITES

During the survey, two historic sites were recorded. Both were homesteads that were occupied prior to the 1940's. One is located in Gillette North and the other in Belle Ayr South.

Site 48CA307, a homestead located in Section 27 in Gillette North, was mentioned (above) in relation to a small cave located near it. In addition to the cave, this site consisted of the remains of two wooden buildings and a collapsed root cellar that had been excavated into the hillside. Near it was an orchard and to the west was a ridge of sandstone outcrops which had been used in several places as a garbage dump. The most common artifacts in the dump areas and around the buildings were old Wyoming license plates. More than 100 of these were found. They spanned the five year period between 1930 and 1934, although most were concentrated in 1931 and 1932. Because of these, we assumed that the farm had been occupied in the 1930's and possibly 1934 was the terminal date. No one in the area knew when it had been occupied or why so many license plates would have been present. Other artifacts found in the area were old bottles, broken crockery, and a roll of Curtis' loop lock barbed wire patented in 1893 but used until recent times in some areas (identification courtesy of Clifton, 1970). This site does not warrant preservation.

Site 48CA325 was a homestead located just southeast of the Belle Ayr Mine in the Belle Ayr South area. Its history is relatively well documented.

There are three structures which make up this site; a small house and the remains of another smaller building (Fig. 16), and a large corral (Fig. 17) located over a steep ridge east of the buildings. An interesting feature of this homestead is that the buildings and corral are constructed of clinkers, the only building material available in the immediate area. The large pieces of this rock are mortared with mud. The AMAX Company is restoring the site to serve as an added visitor attraction for visitors to the mine.

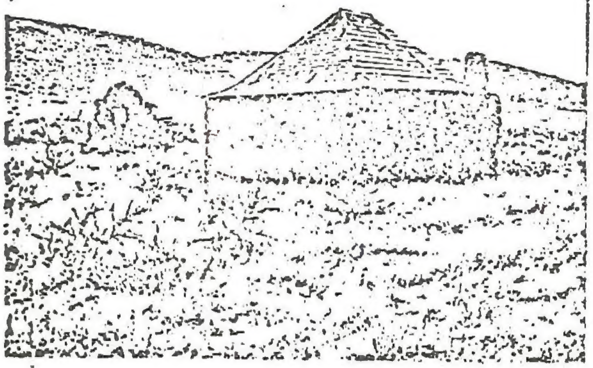


Fig. 16. Clinker homestead, 48CA325, located southeast of Belle Ayr Mine. House, and small building remnant to left, are made of mud-mortared clinker blocks. Restoration of site being undertaken by AMAX Company.

According to information collected by the AMAX Company, this homestead was constructed in 1910 by Joseph DeMaggt, a Belgian immigrant. DeMaggt served in World War I and never returned to Gillette. It is not known if he died during the war. Later, Cereal DeMaggt, a brother to Joseph, took over the homestead and used it as a sheep ranch. It was he who constructed the stone corrals in the 1930's.

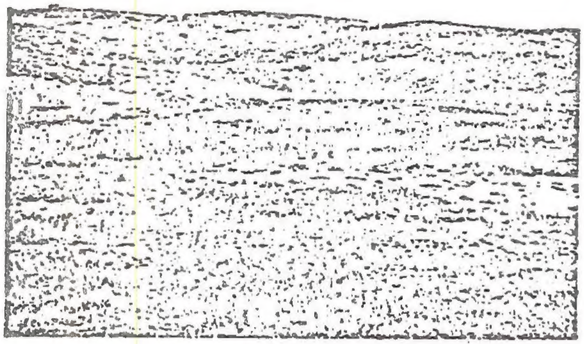


Fig. 17. Clinker corral east of homestead. Sheep corral is located over steep ridge from buildings.

PALEONTOLOGICAL REMAINS

Wyoming abounds with paleontological remains varying from dinosaur bones to fossil leaf beds. The Gillette area is no exception. During the course of our survey, we found and recorded two paleontological sites and picked up a few scattered fragmentary fossils.

The two sites 48CA313 and 48CA314 were both petrified "forests". located in the southern area of Gillette North. During the Tertiary, large trees were rapidly buried in sand. Today they exist as large petrified tree stumps and fallen sections of logs. Some of the stumps are as much as 4 feet in diameter and stand 3½-4 feet high (Fig. 18). Others are smaller and much shorter.

The state of preservation of these trees indicates that they were rapidly buried, and only later exposed, to be broken apart and scattered somewhat by the elements. Evidence of this scattering is apparent in the widely distributed occurrence of pieces of petrified wood found all over both of the survey areas. Local residents indicate that petrified wood is common in the area, and many rock gardens and flower beds in

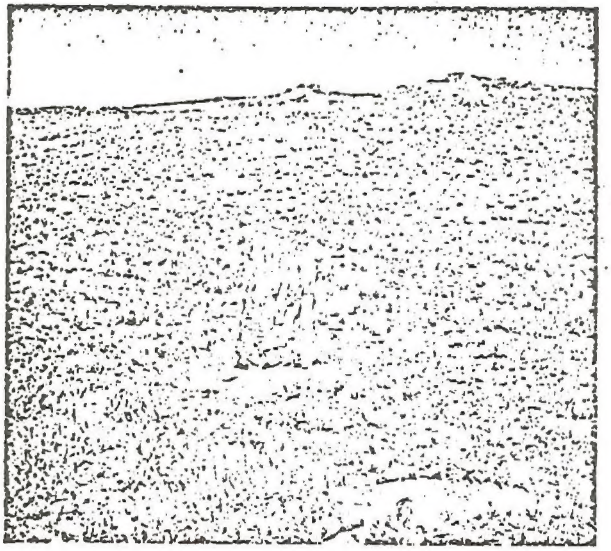


Fig. 18. Petrified tree at 48CA314. Tree is 3½-4 feet high.

Gillette display sizeable pieces. In fact, some of the petrified wood was used by the Indians in tool manufacture.

Other fossil remains found in the area were two fragmentary oyster shells of Cretaceous age picked up in the Belle Ayr South area (Fig. 19). These were classed as random finds.

In conclusion, petrified wood in this area is not rare and not important enough to warrant preservation measures. But if the area of 48CA314 is not of major importance to mining, the site might be preserved to serve as an attraction for visitors to the North Gillette mining operations, much as site 48CA325 is being preserved at the Belle Ayr Mine.

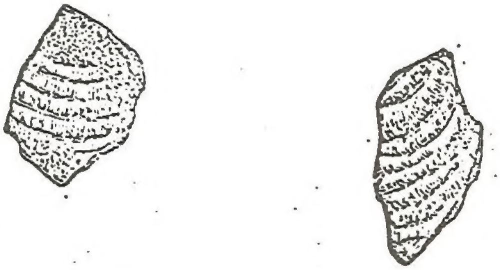


Fig. 19. Fragmentary fossil oyster shells found in Belle Ayr South area.

REFERENCES CITED

Bentzen, Raymond
1962 The Powers-Yonkee Bison Trap. Plains Anthropologist, Vol. 7, No. 16, pp. 113-118.

Brown, Roland W.
1958 Fort Union Formation in the Powder River Basin, Wyoming, in Wyoming Geological Association Guidebook, John Strickland, ed.

Clifton, Robert T.
1970 Barbs, Prongs, Points, Prickers, and Stickers, A Complete and Illustrated Catalogue of Antique Barbed Wire. University of Oklahoma Press.

Frison, George C.
1962 Wedding of the Waters Cave, 48 HO 301, A Stratified Site in the Big Horn Basin of Northern Wyoming. Plains Anthropologist, Vol. 7, No. 18, pp. 246-265.

Husted, Wilfred M.
1968 Wyoming, in The Northwestern Plains: A Symposium, Warren W. Caldwell and Stuart W. Connor, eds. Occasional Papers of the Center for Indian Studies, Rocky Mountain College, No. 1.

Kehoe, Thomas F.
1958 Tipi Rings: The "Direct Ethnological" Approach Applied to an Archaeological Problem. American Anthropologist, Vol. 60, No. 5, pp. 861-873.

Malouf, Carling
1961 The Tipi Rings of the High Plains. American Antiquity, Vol. 26, No. 3, pp. 381-389.

Mapel, William J.
1958 Coal in the Powder River Basin, in Wyoming Geological Association Guidebook, John Strickland, ed.

Mulloy, William T.
1952 The Northern Plains, in Archaeology of Eastern United States, James B. Griffin, ed. University of Chicago Press.

1954 The McKean Site in Northeastern Wyoming, Southwestern Journal of Anthropology, Vol. 10, No. 4, pp. 432-460.

1958 A Preliminary Historical Outline for the Northwestern Plains. University of Wyoming Publications, Vol. XXII, No. 1.

Wheeler, Richard P.
1954 Two New Projectile Point Types: Duncan and Hanna Points. Plains Anthropologist, No. 1, pp. 7-14.

APPENDIX H

Wildlife Survey Data

Source: Amax Coal Company Continuing Environmental Research Studies

Table 1. Mammals which occur or may occur on AMAX controlled properties near Gillette, Wyoming.

COMMON NAME	SCIENTIFIC NAME
INSECTIVORES	
Masked shrew	Sorex cinereus
Vagrant shrew	S. vagrans
*Merriam's shrew	S. merriami
BATS	
Little brown myotis	Myotis lucifugus
Keen's myotis	M. keenii
Long-eared myotis	M. evotis
Long-legged myotis	M. volans
Small-footed myotis	M. subulatus
Silver-haired bat	Lasionycteris noctivagans
*Big brown bat	Eptesicus fuscus
Hoary bat	Lasiurus cinereus
Townsend's bat	Plecotus townsendii
LAGOMORPHS	
**White-tailed jackrabbit	Lapus townsendii
**Black-tailed jackrabbit	L. californicus
**Desert cottontail	Sylvilagus audubonii
**Mountain cottontail	S. nuttallii
**Eastern cottontail	S. floridanus
SMALL RODENTS	
**Least chipmunk	Eutamias minimus
**13-lined ground squirrel	Spermophilus tridecemlineatus
Black-tailed prairiedog	Cynomys ludovicianus
**Northern pocket gopher	Thomomys taipoides
Plains pocket gopher	Geomys bursarius
**Olive-backed pocket mouse	Perognathus fasciatus
Silky pocket mouse	P. flavus
Hispid pocket mouse	P. hispidus
**Ord's kangaroo rat	Dipodomys ordii
Plains harvest mouse	Reithrodontomys montanus
Western harvest mouse	R. megalotis
**Deer mouse	Peromyscus maniculatus
White-footed mouse	P. leucopus
Northern grasshopper mouse	Onychomys leucogaster
**Bushy-tailed woodrat	Neotoma cinerea
**House mouse	Mus musculus
**Meadow vole	Microtus pennsylvanicus
Prairie vole	M. ochrogaster
**Sagebrush vole	Lagurus curtatus
FURBEARERS AND PREDATORS	
**Muskrat	Ondatra zibethicus
*Beaver	Castor canadensis
**Raccoon	Procyon lotor
Short-tail weasel	Mustela erminea
**Long-tail weasel	M. frenata

Table 1

COMMON NAME	SCIENTIFIC NAME
**Mink	M. vison
Black-footed ferret [1,2]	M. nigripes
**Striped skunk	Mephitis mephitis
*Spotted skunk	Spilogale putorius
**Badger	Taxidea taxus
Gray fox	Urocyon cinereoargenteus
**Red fox	Vulpes fulva
Swift fox[1,2]	V. velox
**Coyote	Canis latrans
**Bobcat	Lynx rufus
Mountain lion[2]	Felis concolor
UNGULATES	
**Pronghorn antelope	Antilocapra americana
**Mule deer	Odocoileus hemionus
White-tail deer	O. virginianus

*Species observed on south site 1 January-1 July, 1974.

**Species observed on north site 1 January-1 July, 1974.

1. Federal threatened species (incl. "undetermined").

2. Wyoming threatened species (incl. "undetermined").

Table 2. Birds which occur or may occur on AMAX controlled properties near Gillette, Wyoming. List includes breeding birds, residents, migrants, visitants, and accidentals.

PODICIPEDIDAE	western grebe	Aechmophorus occidentalis
	*horned grebe	Podiceps auritus
	*eared grebe	P. nigricollis
	*pied-billed grebe	Podilymbus podiceps
PELECANIFORMES	white pelican	Pelecanus erythrorhynchos
	double-crested cormorant	Phalacrocorax auritus
ANATIDAE	whistline swan	Olor columbianus
	**Canada goose	Branta canadensis
	white-fronted goose	Anser albifrons
	snow goose	Chen caerulescens
	**mallard	Anas platyrhynchos
	**pintail	A. acuta
	**gadwall	A. strepera
	**American wigeon	A. americana
	**shoveler	A. clypeata
	**blue-winged teal	A. discors
	**green-winged teal	A. crecca
	**cinnamon teal	A. cyanoptera
	**redhead	Aythya americana
	canvasback	A. valisineria
	**ring-necked duck	A. collaris
	greater scaup	A. marila
	**lesser scaup	A. affinis
	**common goldeneye	Bucephala clangula
	Barrow's goldeneye	B. islandica
	**bufflehead	B. albeola
	**ruddy duck	Oxyura jamaicensis
	common merganser	Mergus merganser
	red-breasted merganser	M. serrator
	hooded merganser	Lophodytes cucullatus
CATHARTIDAE	turkey vulture[2]	Cathartes aura
ACCIPITRIDAE	goshawk[2]	Accipter gentilis
	Copper's hawk	A. cooperii
	sharp-shinned hawk	A. striatus
	**marsh hawk	Circus cyaneus
	**rough-legged hawk	Buteo lagopus
	**ferruginous hawk[1,2]	B. regalis
	**red-tailed hawk	B. jamaicensis
	Swainson's hawk[2]	B. swainsoni
	**golden eagle	Aquila chrysaetos
	**bald eagle[2]	Haliaeetus leucephalus
PANDIONIDAE	osprey[2]	Pandion haliaetus
FALCONIDAE	prairie falcon[1,2]	Falco mexicanus
	peregrine falcon[1,2]	F. peregrinus
	merlin[1]	F. columbarius
	**American kestrel	F. sparverius

Table 2

FAMILY	COMMON NAME	SCIENTIFIC NAME
STRIGIDAE	**great horned owl	Bubo virginianus
	screech owl[2]	Otus asio
	long-eared owl	Asic otus
	short-eared owl[2]	A. flammeus
	barred owl	Strix varia
	burrowing owl[1,2]	Speotyto cunicularia
	saw-whet owl[2]	Aegolius acadicus
TETRAONIDAE	**sage grouse	Centrocercus urophasianus
	sharp-tailed grouse[2]	Pedioecetes phasianellus
PHASIANIDAE	ring-necked pheasant.	Phasianus colchicus
	**gray partridge	Perdix perdix
ARDEIDAE	**great blue heron	Ardea herodias
	black-crowned night heron[2]	Nyctiocorax nycticorax
	American bittern	Botaurus lentiginosus
GRUIDAE	sandhill crane	Grus canadensis
RALLIDAE	Virginia rail	Rallus limicola
	sora	Porzana carolina
	yellow rail	Coturnicops noveboracensis
	**American coot	Fulica americana
RECURVIROSTRIDAE	American avocet	Recurvirostra americana
CHARADRIIDAE	mountain plover[2]	Charadrius montana
	American golden plover	Pluvialis dominica
	black-bellied plover	Squatarola squatarola
	semipalmated plover	C. semipalmatus
	**killdeer	C. vociferus
SCOLOPACIDAE	*long-billed curlew[2]	Numenius americanus
	marbled godwit	Limosa fedoa
	Hudsonian godwit	L. haemastica
	upland plover[2]	Bartramia longicauda
	buff-breasted sandpiper	Tryngites subruficollis
	*solitary sandpiper	Tringa solitaria
	**spotted sandpiper	Actitis macularia
	willet	Catoptrophorus semipalmatus
	greater yellowlegs	T. melanoleucus
	lesser yellowlegs	T. flavipes
	stilt sandpiper	Micropalama himantopus
	short-billed dowitcher	Limnodromus griseus
	*long-billed dowitcher	L. scolopaceus
	sanderling	Crocethia alba
	pectoral sandpipe	Calidris melanotos
	*Baird's sandpiper	C. bairdii
	white-rumped sandpiper	C. fusciocollis
	least sandpiper	C. minutilla
	semipalmated sandpiper	C. pusillus
	western sandpiper	C. mauri
PHALAROPODIDAE	**Wilson's phalarope	Steganopus tricolor
	*northern phalarope	Lopipes lobatus

Table 2

FAMILY	COMMON NAME	SCIENTIFIC NAME
SCOLOPACIDAE	common snipe	Capella gallinago
LARIDAE	*herring gull	Larus argentatus
	*California gull	L. californicus
	ring-billed gull	L. delawarensis
	Franklin's gull	L. pipixcan
	Bonaparte's gull	L. philadelphia
	Forster's tern	Sterna forsteri
	caspian tern	Hydroprogne caspia
	*black tern	Chlidonias niger
COLUMBIDAE	**rock dove	Columba livia
	**morning dove	Zenaida macroura
CUCULIDAE	yellow-billed cuckoo	Coccyzus americanus
	black-billed cuckoo	C. erythrophthalmus
CAPRIMULGIDAE	**common nighthawk	Chordeiles minor
	poor-will	Phalaenoptilus nuttallii
APODIDAE	chimney swift	Chaetura pelagica
	white-throated swift	Aeronautes sakatalis
TROCHILIDAE	broad-tailed hummingbird	Selasphorus platycercus
ALCEDINIDAE	**belted kingfisher	Megaceryle alcyon
PICIDAE	**common flicker	Colaptes auratus
	*red-headed woodpecker	Melanerpes erythrocephalus
	Lewis' woodpecker	Asyndesmus lewis
	yellow-bellied sapsucker	Sphyrapicus varius
	hairy woodpecker	Dendrocopos villosus
	downy woodpecker	D. pubescens
TYRANNIDAE	**eastern kingbird	Tyrannus tyrannus
	**western kingbird	T. verticalis
	eastern phoebe	Sayornis phoebe
	**Say's phoebe	S. saya
	*willow flycatcher	Empidonax traillii
	least flycatcher	E. minimum
	dusky flycatcher	E. oberholseri
	western flycatcher	E. difficilis
	eastern wood pewee	Contopus virens
	western wood pewee	C. sordidulus
	olive-sided flycatcher	Nuttallornis borealis
ALAUDIDAE	**horned lark	Eremophila alpestris
HIRUNDINIDAE	**barn swallow	Hirundo rustica
	**cliff swallow	Petrochelidon pyrrhonota
	tree swallow	Iridoprocne bicolor
	bank swallow	Riparia riparia
	rough-winged swallow	Stelgidopteryx ruficollis
	purple martin	Progne subis
CORVIDAE	**black-billed magpie	Pica pica
	**common crow	Corvus brachyrhynchos

Table 2

FAMILY	COMMON NAME	SCIENTIFIC NAME
PARIDAE	*black-capped chickadee	Parus atricapallus
SITTIDAE	white-breasted nuthatch	Sitta carolinensis
	red-breasted nuthatch	S. canadensis
CERTHIIDAE	brown creeper	Certhia familiaris
TROGLODYTIDAE	*house wren	Troglodytes aedon
	**rock wren	Salpinctes obsoletus
	canyon wren	Catherpes mexicanus
	long-billed marsh wren	Telmatodytes palustris
MIMIDAE	*catbird	Dumetella carolinensis
	**brown thrasher	Toxostroma rufum
	**sage thrasher	Oreoscoptes montanus
TURDIDAE	**American robin	Turdus migratorius
	Townsend's solitaire	Myadestes townsendi
	**hermit thrush	Catharus guttata
	Swainson's thrush	C. ustulata
	gray-cheeked thrush	C. minima
	veery	C. fuscesceus
	eastern bluebird	Sialia sialis
	western bluebird	S. mexicana
	**mountain bluebird	S. currucoides
SYLVIIDAE	golden-crowned kinglet	Regulus satrapa
	ruby-crowned kinglet	R. calendula
MOTACILLIDAE	Water pipit	Anthus spinoletta
	Sprague's pipit	A. spragueii
BOMBYCILLIDAE	Bohemian waxwing	Bombycilla garrulus
	cedar waxwing	B. cedrorum
LANIIDAE	**loggerhead shrike	Lanius ludovicianus
	northern shrike	L. excubitor
STURNIDAE	**starling	Sturnus vulgaris
VIREONIDAE	solitary vireo	Vireo solitarius
	red-eyed vireo	V. olivaceus
	warbling vireo	V. gilvus
PARULIDAE	black and white warbler	Minotilta varia
	Tennessee warbler	Vermivora peregrina
	orange-crowned warbler	V. celata
	Nashville warbler	V. ruficapilla
	Virginia's warbler	V. virginiae
	*yellow warbler	Dendroica petechia
	magnolia warbler	D. magnolia
	*yellow-rumped warbler	D. coronata
	black-throated gray warbler	D. nigresceus
	*chestnut-sided warbler	D. pensylvanica
	bay-breasted warbler	D. castanea
	blackpoll warbler	D. striata
	palm warbler	D. palmarum

Table 2

FAMILY	COMMON NAME	SCIENTIFIC NAME
	ovenbird	Seiurus aurocapillus
	northern water thrush	S. noveboracensis
	**common yellowthroat	Geothlypis trichas
	yellow-breasted chat	Icteria virens
	Macgillivray's warbler	Oporornis tolmiei
	mourning warbler	O. philadelphia
	Wilson's warbler	Wilsonia wilsonia
	*American redstart	Setophaga ruticilla
PLOCEIDAE	**house sparrow	Passer domesticus
ICTERIDAE	*bobolink	Dolichonyx oryzivorus
	**western meadowlark	Sturnella neglecta
	**yellow-headed blackbird	Xanthocephalus xanthocephalus
	**red-winged blackbird	Agelaius phoeniceus
	rusty blackbird	Euphagus carolinus
	**Brewer's blackbird	E. cyanocephalus
	**common grackle	Quiscalus quiscula
	**brown-headed cowbird	Molothrus ater
	*Bullock's oriole	Icterus galbula
THRAUPIDAE	*western tanager	Piranga ludoviciana
FRINGILLIDAE	*black-headed grosbeak	Pheucticus melanocephalus
	evening grosbeak	Hesperiphona vespertina
	lazuli bunting	Passerina amoena
	purple finch	Carpodacus purpureus
	Cassin's finch	C. cassinii
	house finch	C. mexicanus
	*gray-crowned rosy finch	Leucosticte tephrocotis
	common redpoll	Acanthis flammea
	pine siskin	Spinus pinus
	**American goldfinch	S. tristis
	red crossbill	Loxia curvirostra
	dickcissel	Spiza americana
	green-tailed towhee	Chlorura chlorura
	rufous-sided towhee	Pipilo erythrophthalmus
	savannah sparrow	Passerculus sandwichensis
	**grasshopper sparrow	Ammodramus savannarum
	Baird's sparrow	A. bairdii
	**lark bunting	Calamospiza melanocorys
	**vesper sparrow	Pooecetes gramineus
	**lark sparrow	Chondestes grammacus
	**sage sparrow	Amphispiza belli
	**dark-eyed junco	Junco hyemalis
	**tree sparrow	Spizella arborea
	**chipping sparrow	S. passerina
	**clay-colored sparrow	S. pallida
	**Brewer's sparrow	S. breweri
	field sparrow	S. pusilla
	Harris' sparrow	Zonotrichia querula
	*white-crowned sparrow	Z. leucophrys
	white-throated sparrow	A. albicollis
	fox sparrow	Passerella iliaca
	Lincoln's sparrow	Melospiza lincolnii
	song sparrow	M. melodia
	**McCown's longspur	Calcarius mccownii

Table 2

FAMILY	COMMON NAME	SCIENTIFIC NAME
	**Chestnut-collared longspur	C. ornatus
	lapland longspur	C. lapponicus
	Smith's longspur	C. pictus
	snow bunting	Plectrophenax nivalis

* Species observed on south AMAX properties 1 January 1974 - 1 July 1974.
** Species observed on north AMAX properties 1 January 1974 - 1 July 1974.

1. Federal threatened species (incl. "undetermined").

2. Wyoming threatened species (incl. "undetermined").

Table 3. Threatened[1] and "Blue List"[2] species found on north and south AMAX sites near Gillette, Wyoming as of August, 1974.

LIST	SPECIES	GENERAL STATUS[3]	ON-SITE STATUS
Federal	**Ferruginous Hawk	U	Uncommon, year around resident. Nests on site.
State	**Bald Eagle	U	Common winter resident.
	**Ferruginous Hawk	U	See Federal
	*Long-billed curlew	U	Uncommon migrant.
Blue List	**Ferruginous Hawk	D	See Federal
	**Marsh Hawk	S	Common breeding bird.
	**American Kestrel	S	Common spring-summer resident
	**Sage grouse	D	Common year around; breeds on-site.
	**Loggerhead shrike	S	Uncommon spring-summer resident; breeds near windbreaks.
	*Yellow warbler	S	Common spring-summer resident; breeds in wind-breaks.
	**Common yellowthroat	S	Common spring-summer; breeds in wind-breaks and brushy draws.
	**Grasshopper sparrow	S	Uncommon breeding bird.
	*Gray-crowned rosy finch	U	Uncommon winter visitant.

---

[1] Federal List (Office of Endangered Species 1973) and Wyoming list (Wyoming Game and Fish Dept. 1973).

[2] Audubon Society - Federal Fish and Wildlife Service list of birds with regionally declining populations (Arbib 1973).

[3] Population status for Northern Great Plains Region. U = Undetermined; S = Stable; D = Declining.

*Observed on south site.

**Observed on north site.

Table 4. Mammals inhabiting (observation-sign) AMAX controlled properties near Gillette, Wyoming.

Species	Preferred habitat on/about AMAX properties
Merriam's shrew[1,2]	sage-grass slopes
big brown bat[2]	rocky bluffs and cliffs
white-tailed jackrabbit[1,2]	sage-grass ecotones
black-tailed jackrabbit[1,2]	sage areas
eastern cottontail[1,2]	stream bottoms-human dwellings
mountain cottontail[1,2]	sage; grass areas near rocks
desert cottontail[1,2]	sage; grass areas near rocks
least chipmunk[1,2]	rocky draws and buttes
13-lined ground squirrel[1,2]	grass areas - varied
northern pocket gopher[1,2]	friable soil on south exposures
olive-backed pocket mouse[1,2]	grass areas
Ord's kangaroo rat[1,2]	grass areas, some sage, friable soil
deer mouse[1,2]	varied; grass-sage
bushytail woodrat[1,2]	rocky draws
house mouse[2]	near human dwellings
meadow vole[1,2]	grass bottoms
sagebrush vole[1,2]	sage; sage-grass
*muskrat[1,2]	lake-creek-stockponds
*beaver[2]	creeks-cattail marsh areas
long-tail weasel[1,2]	varied; rock areas, creek bottoms
*mink[2]	riparian areas
*striped skunk[1,2]	varied; rocky draws, abandoned dwelling
*spotted skunk[2]	varied; rocky areas
*badger[1,2]	grass hillsides near rocky areas
*red fox[1,2]	varied; sage-grass-rocks
*coyote[1,2]	varied; sage-grass-rocks
*bobcat[1,2]	varied; rocky areas
pronghorn antelope[1,2]	varied; sage-grass
mule deer[1,2]	varied; creek bottoms, sage-grass
*raccoon[1,2]	riparian; rocky draws off creek bottom.

*furbearers of commercial importance

[1] North site

[2] South site

Table 5. Antelope aerial census data; North and South sites.

Date		North Site (3000 acres)	South Site (7000 acres)
4/19/74		318 total	645 total
	Density/640 a.	67	59
8/15/74		80 total	309 total
	Adult	67	223
	Young	13	86

Table 9. Small mammal captures (TC) and minimum density (MDI)[1] by major cover type for *winter* period[1], 1974. South Site.

Cover Type	Number of Plots	Total Acres	deer mouse		13-lined ground squirrel		Sagebrush vole		Merriam's shrew			
			TC	MDI	TC	MDI	TC	MDI	TC	MDI	Totals	MDI
Sagebrush	12	51.0	80	1.6	5	0.1	5	0.1	2	<0.1	92	1.8
Grassland	2	8.5	36	4.2	-	-	3	0.4	-	-	39	4.6
Cultivated; seeded to grass	5	21.3	25	1.2	-	-	-	-	-	-	25	1.2
Cultivated; winter wheat	2	8.5	13	1.5	-	-	-	-	-	-	13	1.3
Totals	21	89.3	154	1.7	5	<0.1	8	0.1	2	<0.1	169	1.9

---

[1] MDI based on 4.25 acre plot size.

Table 10. Small mammal captures (TC) and minimum density indexes (MDI)[1] by major cover type for spring period[1], 1974. South Site.

Cover Type	Number of Plots	Total Acres	deer mouse		13-lined ground squirrel		Sagebrush vole		house mouse		olive-backed pocket mouse		northern pocket gopher			
			TC	MDI	TC	MDI	TC	MDI	TC	MDI	TC	MDI	TC	MDI	Totals	MDI
Sagebrush	12	51.0	58	1.2	14	0.3	1	<0.1	1	<0.1	1	<0.1	1	<0.1	76	1.6
Grassland	2	8.5	26	3.1	1	0.1	1	0.1	-	-	-	-	-	-	28	3.3
Cultivated; seeded to grass	5	21.3	15	0.7	4	0.2	-	-	-	-	-	-	-	-	19	0.9
Cultivated; winter wheat	2	8.5	19	2.2	-	-	-	-	-	-	5	0.6	-	-	24	2.8
Totals	21	89.3	118	1.4	19	0.2	2	<0.1	1	<0.1	6	0.1	1	<0.1	147	1.7

[1] MDI based on 4.25 acre plot size.

Table 11. Small mammal captures (TC) and minimum density indexes (MDI)[1] by major cover type for summer period[1], 1974. South Site.

Cover Type	Number of Plots	Total Acres	deer mouse		13-lined ground squirrel		Sage-brush		Northern grass-hopper mouse		olive-backed pocket mouse		Merriam's shrew			
			TC	MDI	TC	MDI	TC	MDI	TC	MDI	TC	MDI	TC	MDI	Totals	MDI
Sagebrush	12	51.0	93	1.8	49	1.0	2	<0.1	13	0.3	-	-	-	-	157	3.1
Grassland	2	8.5	18	2.1	-	-	-	-	3	0.4	-	-	1	0.1	22	2.6
Cultivated; seeded to grass	5	21.3	34	1.6	23	1.1	-	-	9	0.4	-	-	-	-	66	3.1
Cultivated; winter wheat	2	8.5	34	4.0	-	-	-	-	1	0.1	1	0.1	-	-	36	4.2
Totals	21	89.3	179	2.0	72	0.8	2	<0.1	26	0.3	1	<0.1	1	<0.1	281	3.1

[1] MDI based on 4.25 acre plot size.

Table 55

Fall Enrollment, Pupils/Teacher Ratio, and Number of Public Schools in Powder River Basin Counties, Region, and State for Fall 1973

County or Area	Fall Enrollment	Pupils/ Teacher	Number of Schools				
			Sr.High	Jr.High	Elementary	Special	Total
Campbell							
1 Gillette	3,060	15.0	1	1	19	-	21
Converse							
1 Douglas	1,104	15.5	1	1	9	-	11
2 Glenrock	679	21.4	1	1	4	-	6
Crook							
1 Sundance	1,187	14.1	3	3	10	-	16
Johnson							
1 Buffalo	1,209	16.3	2	-	7	-	9
Natrona							
1 Casper	13,181	21.5	3	3	28	2	36
Niobrara							
1 Lusk	616	14.4	1	1	8	-	10
Sheridan							
1 Ranchester	660	15.7	2	2	4	-	8
2 Sheridan	3,291	20.3	1	2	8	1	12
3 Clearmont	123	8.0	1	-	2	-	3
Weston							
1 Newcastle	1,266	16.1	1	1	3	-	5
7 Upton	378	13.5	1	1	1	-	3
Region	26,754	18.5	18	16	103	3	140
State Totals	85,391	18.7	71	42	268	5	386

Source: Wyoming State Department of Education, Division of Management Information Services (1974).

County	Total Year-Round Housing Units	Median*	Less Than $5,000	$5,000-9,999	$10,000-14,999	$15,000-19,999	$20,000-24,999	$25,000-34,999	$35,000-or More
Campbell	713	$20,700	14	60	117	140	190	92	100
Urban	678	20,819	8	55	117	122	190	92	94
Rural	35	18,400	6	5	-	18	-	-	6
Converse	815	15,100	58	176	165	247	81	69	19
Urban	460	15,332	34	82	104	131	34	60	15
Rural	355	14,800	24	94	61	116	47	9	4
Crook	390	11,300	20	144	71	110	22	9	14
Urban	---	---	---	---	---	---	---	---	---
Rural	390	11,300	20	144	71	110	22	9	14
Johnson	808	15,800	35	166	166	182	96	97	66
Urban	693	15,949	28	138	143	177	74	77	56
Rural	115	14,900	7	28	23	5	22	20	10
Natrona	9,387	17,000	271	1,038	2,284	2,651	1,470	1,076	597
Urban	7,926	17,869	107	652	1,960	2,385	1,328	955	541
Rural	1,459	12,300	164	386	324	266	142	121	56
Niobrara	465	8,400	132	148	114	39	3	29	---
Urban	---	---	---	---	---	---	---	---	---
Rural	465	8,400	132	148	114	39	3	29	---
Sheridan	3,112	13,700	250	723	720	592	409	289	129
Urban	2,385	13,365	149	592	584	461	299	227	73
Rural	727	14,800	101	131	136	131	110	62	56
Weston	865	10,000	136	298	206	113	40	40	32
Urban	577	11,248	59	172	162	82	30	30	32
Rural	288	7,500	77	126	44	21	10	10	-
Study Area	16,555	15,645**	916	2,753	3,843	4,074	2,311	1,701	957
State	48,200	15,400	2,856	8,171	11,861	12,166	6,273	4,620	2,253

*Median value for urban areas is computed value and represents the difference between the product of total county year-round units and its median value and the product of rural year-round housing units and its median value which is divided by the number of urban units.

**A computed value which is the summation of the products by county of total year-round housing units and respective median value which is divided by total year-round units in the study area.

Source: Detailed Housing Characteristics, Wyoming, 1970 Census of Housing, Tables 34, 61.

Table 53

1970 Value of Owner Occupied Housing by County in the Powder River Basin, Wyoming

Table 50

1970 Structural Characteristics of Housing by County in the Powder River Basin, Wyoming

County	Total Year-Round Units	Single Family	Percent Single Family	Multi-Family	Percent Multi-Family	Mobile Homes	Percent Mobile Homes
Campbell	3,937	1,782	45.3	491	12.5	1,664	42.3
Urban	2,228	1,074	48.2	441	19.8	713	32.0
Rural	1,709	708	41.4	50	2.9	951	55.6
Converse	2,247	1,741	77.5	254	11.3	252	11.2
Urban	1,029	754	73.3	170	16.5	105	10.2
Rural	1,218	987	81.0	84	6.9	147	12.1
Crook	1,576	1,143	72.5	112	7.1	321	20.4
Urban	---	---	---	---	---	---	---
Rural	1,576	1,143	72.5	112	7.1	321	20.4
Johnson	2,158	1,684	78.0	277	12.8	197	9.1
Urban	1,319	1,009	76.5	254	19.3	56	4.2
Rural	839	675	80.5	23	2.7	141	16.8
Natrona	17,228	12,801	74.3	3,206	18.6	1,221	7.1
Urban	13,426	10,222	76.1	2,999	22.3	205	1.5
Rural	3,802	2,579	67.8	207	5.4	1,016	26.7
Niobrara	1,330	1,153	86.7	109	8.2	68	5.1
Urban	---	---	---	---	---	---	---
Rural	1,330	1,153	86.7	109	8.2	68	5.1
Sheridan	6,799	5,528	81.3	1,023	15.0	248	3.6
Urban	4,434	3,446	77.7	929	21.0	59	1.3
Rural	2,365	2,082	88.0	94	4.0	189	8.0
Weston	2,188	1,698	77.6	200	9.1	290	13.3
Urban	1,268	998	78.7	159	12.5	111	8.8
Rural	920	700	76.1	41	4.5	179	19.5
Study Area	37,463	27,530	73.5	5,672	15.1	4,261	11.4
State	114,572	84,457	73.7	19,859	17.3	10,256	9.0

Source: Detailed Housing Characteristics, Wyoming, 1970 Census of Housing, Tables 35, 62.

		Campbell County		Converse County		Crook County		Johnson County		Natrona County	
Group	Family Income	% By Group	# Families	% By Group	# Families	% By Group	# Families	% By Group	# Families	% By Group	# Families
	Less than $1,000		53		47		41		17		236
	$1,000 to $1,999		33		62		54		67		272
I	$2,000 to $2,999		61		87		47		109		442
	$3,000 to $3,999		84		119		87		100		496
	$4,000 to $4,999	10.2%	83	23.6%	58	25.3%	81	24.8%	81	15.2%	544
	$5,000 to $5,999		132		91		141		122		612
II	$6,000 to $6,999		181		83		115		136		761
	$7,000 to $7,999	14.0%	119	19.6%	136	28.8%	97	23.6%	98	17.6%	932
III	$8,000 to $8,999		221		114		120		93		893
	$9,000 to $9,999	15.2%	249	13.5%	99	13.6%	46	10.9%	72	14.0%	952
IV	$10,000 to $11,999	16.2%	501	18.3%	290	13.2%	161	10.9%	165	14.8%	1937
V	$12,000 to $14,999	18.2%	560	14.9%	236	9.9%	121	10.7%	162	16.2%	2131
	$15,000 to $24,999		610		132		108		211		2415
VI	$25,000 to $49,999		150		28		55		40		395
	$50,000 or more	26.2%	48	10.1%	---	9.2%	---	19.0%	36	22.3%	114
	Total Families		3085		1582		1224		1509		13132
	Median Income		$11,303		$8,947		$7,474		$8,263		$10,440
	Mean Income		$12,949		$9,191		$8,153		$11,389		$11,388
	Per Capita Income		$ 3,334		$2,709		$2,415		$ 3,421		$ 3,244

Source: U.S. Department of Commerce, Bureau of Census, Census of Population: 1970 (1971a).

Table 48

Income Data by County
1970

Table 47

Employment Summary, Campbell and Converse Counties

	Campbell County			Converse County		
	1960	1970*		1960	1970*	
Population	5,861	12,957		6,366	5,938	
Employment						
Agriculture	670	601	(12.5%)	580	486	(22.4%)
Petrochemicals						
Petroleum and Natural gas	224	1,364	(28.4)	177	204	(9.4)
Synthetic Gas	-----	------		-----	-----	
Coal Mining	32	32	(0.7)	17	39	(1.8)
Uranium Mining and Milling	2	------		30	71	(3.3)
Power Generation	-----	40	(0.8)	25	-----	
Other Mining	-----	------		-----	-----	
Other Manufacturing	18	131	(2.7)	16	16	(0.7)
Railroads	22	11	(0.3)	25	6	(0.3)
Construction	189	268	(5.6)	192	225	(10.4)
Other Residentiaries	1,120	2,356	(49.1)	1,345	1,121	(51.7)
Total Employment	2,277	4,803	(100.1)	2,407	2,168	(100.0)

*Percentage of employment by sector in parentheses for 1970.

Source: University of Wyoming, Water Resources Research Institute (1974).

Table 45

Urban & Rural Population by County
Powder River Basin Region
1970

	Urban* Population	%	Rural Population	%
Campbell	7,194	55.5	5,763	44.5
Converse	2,677	45.1	3,261	54.9
Crook	0	----	4,535	100.0
Johnson	3,394	60.7	2,193	39.3
Natrona	39,361	76.8	11,903	23.2
Niobrara	0	----	2,924	100.0
Sheridan	10,856	60.8	6,996	39.2
Weston	3,432	54.4	2,875	45.6
Region	66,914	62.3	40,450	37.7
State	201,111	60.5	131,305	39.5

*Places with 2,500 people or more.

Source: U.S. Bureau of the Census, Census of Population, 1970.

Table 44

Population Changes of Powder River Basin Counties & Places Within Counties 1950 - 1970

	1950	1960	% Changes 1950-1960	1970	% Changes 1960-1970
Campbell County	4,839	5,861	21.1	12,957	121.1
Gillette	2,191	3,580	63.4	7,194	100.9
Converse County	5,933	6,366	7.3	5,938	-6.7
Douglas	2,544	2,822	10.9	2,677	-5.1
Glenrock	1,110	1,584	42.7	1,515	-4.4
Crook County	4,738	4,691	-1.0	4,535	-3.3
Sundance	893	908	1.7	1,056	16.3
Moorcroft	517	826	59.8	981	18.8
Johnson County	4,707	5,475	16.3	5,587	2.0
Buffalo	2,674	2,907	8.7	3,394	16.8
Natrona County	31,437	49,623	57.8	51,264	3.3
Casper	23,673	38,930	64.4	39,361	1.1
Mills	866	1,477	70.6	1,724	16.7
Mountain View	-----	1,721	----	1,641	-4.6
Paradise Valley	-----	-----	----	1,764	----
Evansville	393	678	72.5	832	22.7
Edgerton	203	512	152.2	350	-31.6
Niobrara County	4,701	3,750	-20.2	2,924	-22.0
Lusk	2,089	1,890	-9.5	1,495	-20.9
Sheridan County	20,185	18,989	-5.9	17,852	-6.0
Sheridan	11,500	11,651	1.3	10,856	-6.0
Dayton	316	333	5.4	396	18.9
Ranchester	251	235	-6.3	208	-11.5
Clearmont	225	154	-31.6	141	-8.4
Weston County	6,733	7,929	17.8	6,307	-20.5
Newcastle	3,395	4,345	28.0	3,432	-21.0
Upton	951	1,224	28.7	987	-19.4
8 County Region	83,273	102,684	23.3	107,364	4.5
State	290,529	330,066	13.6	332,416	0.7

Source: U. S. Department of Commerce, Bureau of the Census, *Census of Population, 1950* through *1970*.

	1950	Percent of Region Total	1960	Percent of Region Total	1970	Percent of Region Total
Campbell	4,839	5.8	5,861	5.7	12,957	12.1
Converse	5,933	7.1	6,366	6.2	5,938	5.5
Crook	4,738	5.7	4,691	4.6	4,535	4.2
Johnson	4,707	5.7	5,475	5.3	5,587	5.2
Natrona	31,437	37.8	49,623	48.3	51,264	47.8
Niobrara	4,701	5.6	3,750	3.7	2,924	2.7
Sheridan	20,185	24.2	18,989	18.5	17,852	16.6
Weston	6,733	8.1	7,929	7.7	6,307	5.9
Regional Total	83,273	100.0	102,684	100.0	107,364	100.0
State Total	290,529	-----	330,066	-----	332,416	-----

Source: U.S. Department of Commerce, Bureau of the Census, Census of Population, 1950 through 1970.

Table 43

Population Distribution of Wyoming Counties
Powder River Basin
1950 - 1970

APPENDIX I

Selected Regional Socio-Economic Data

Source: FES 74-55

Table 20. Herptiles which occur or may occur on AMAX controlled properties near Gillette, Wyoming

COMMON NAME	SCIENTIFIC NAME
AMPHIBIANS	
Tiger salamander	Ambystoma tigrinum
Central plains spadefoot	Scaphiopus bombitrons
Woodhouse's toad	Buto woodhousei
Great plains toad	B. cognatus
**chorus frog	Pseudacris triseriata
**Leopard frog	Rana pipiens
REPTILES	
**Short-horned lizard	Phrynosoma douglassi
Sagebrush lizard	Sceloporus graciosus
Racer	Coluber constrictor
Western hog-nose snake	Heterodon nasicus
Milk snake	Lampropeltis triangulum
Bullsnake	Pituophis melanoleucus
Common garter snake	Thamnophis sirtalis
Plains garter snake	T. radix
**Western garter snake	T. elegans
**Western (prairie) rattlesnake	Crotalus viridis
Painted turtle	Chrysemys picta
Snapping turtle	Chelydra serpentina
Spiny soft-shelled turtle	Trionyx spiniferus

* species observed on south site as of 1 January-1 July, 1974.

** species observed on north site as of 1 January-1 July, 1974.

Table 19. Numbers and % relative abundance of 28 species of songbirds captured on south AMAX properties near Gillette, Wyoming. April-June, 1974.

SPECIES	NUMBERS CAPTURED[1]	% RELATIVE ABUNDANCE[2]
Lark bunting	47	26
Lark sparrow	40	22
Chipping sparrow	18	10
Mourning dove	10	6
Brewer's sparrow	9	5
Clay-colored sparrow	6	3
Western meadowlark	6	3
Loggerhead shrike	5	3
Horned lark	5	3
American goldfinch	4	2
Vesper sparrow	3	2
American robin	3	2
Yellow warbler	3	2
Red-winged blackbird	2	1
Audubon's warbler	2	1
White-crowned sparrow	2	1
Hermit thrush	2	1
Brown thrasher	2	1
Tree sparrow	1	1
Brewer's blackbird	1	1
Western tanager	1	1
Bullock's oriole	1	1
Black-headed grosbeak	1	1
American redstart	1	1
Common yellowthroat	1	1
Chestnut-sided warbler	1	1
Willow flycatcher	1	1
Say's phoebe	1	1
TOTALS: 28 species	179	104[3]

[1] Captured by mist nets and traps.

[2] % of total captured.

[3] >100%: artifact of rounding.

Table 18. Breeding pair densities/100 acres and relative densities (% RD) of major breeding songbirds for three general vegetal types on South AMAX site, April-June, 1974.

Species	Sagebrush	%RD	Grass[1]	%RD	Cultivated Seeded Grass	%RD	Total Breeding Pairs	$\bar{X}$[1]	Total[2] %RD
Horned lark	20	21	10	20	40	89	70	23	37
Vesper sparrow	20	21	20	40	--	--	40	13	21
Brewer's sparrow	30	31	--	--	--	--	30	10	16
Western meadowlark	10	11	15	30	--	--	25	8	13
Lark bunting	15	16	--	--	--	--	15	5	8
McCown's longspur	--	--	--	--	5	11	5	2	3
Rock wren[3]	--	--	5	10	--	--	5	2	3
Totals:	95	100	50	100	45	100	190	63	101

[1] Mean breeding pairs/100 acres from all samples vegetal types.

[2] % RD for South Property.

[3] Attributed to rocky ridges on plot edge.

Table 16. Results of waterfowl breeding pair survey conducted on Rawhide Creek and Caballo Creek, May-June, 1974.

Species	Caballo Creek[1]	Rawhide Creek[2]
Mallard	11	5
blue-winged teal	6	6
American wigeon	4	5
green-winged teal	4	-
pintail	1	3
gadwall	2	-
cinnamon teal	1	-
shoveler	1	1
lesser scaup	-	3
redhead	1	-
American coot	2	-
Totals	33	23

[1] breeding pairs -- south site.

[2] breeding pairs -- north site.

Table 14. Duirnal raptor road census data, North and South AMAX-Gillette site. Late Winter, 1974.

Date	Rt. Miles[1]	Golden Eagle	Bald Eagle	Rough-legged hawk	Red-tailed hawk	Marsh Hawk	Am. Kestrel	Total	Total diurnal raptors per 100 sq. miles
South Site									
3/5/74	20*	3	-	1	-	-	-	4	40
3/16/74	20*	2	-	-	-	-	-	2	20
3/23/74	20*	2	-	1	4	1	-	8	80
3/30/74	20*	3	1	4	-	2	1	11	110
4/14/74	20*	2	-	-	-	1	-	3	30
Totals & Averages[2]	100.0*	12(24)	1(2)	6(12)	4(8)	4(8)	1(2)	28	(56)[3]
North Site									
3/16/74	7.5**	-	-	-	-	-	-	-	-
3/30/74	7.5**	-	1	1	-	-	-	2	2
4/14/74	7.5**	2	-	-	-	2	-	4	8
Totals & Averages	22.5	2(18)	1(9)	1(9)	-	2(18)	-	6	(53)[3]

---

[1] 0.25 miles checked on each side of route = 10 square miles/south site & 3.75 square miles/north site.

[2] Average species totals/100 square miles in parentheses.

[3] Average total diurnal raptors/100 square miles.

* South Site.

**North Site only.

Table 13. Checklist of birds (Con't)

SPECIES	No. Banded[2]	Status[1]	Preferred Habitat On/About AMAX Properties
*Western tanager	1	U-V	■
*Gray-crowned rosy finch	-	U-WR	Buildings; windrows
**American goldfinch	4	C-V	Thick, tall shrubs, trees; open windrows
*Black-headed grosbeak	1	U-V	Open, short brush near water
**Lark bunting	47	B-SR	Varied; open sage-grass buildings; open windrows
**Grasshopper sparrow	-	B-SR	Open; sage-grass
**Vesper sparrow	3	B-SR	Open; sage-grass; windrows
*White-crowned sparrow	2	U-SR	Buildings; windrows
**Lark sparrow	40	B-SR	Open; sage-grass
**Sage sparrow	-	U-V	■
**Tree sparrow	1	C-WR	Buildings; windrows
**Chipping sparrow	18	C-V	Varied; sage-grass open windrows
**Brewer's sparrow	9	B-SR	Open; sage-grass; windrows
**Clay-colored sparrow	6	C-V	Open; sage-grass; windrows
**Dark-eyed junco	-	C-WR	Varied; windrows; buildings
**McCowan's longspur	-	B-SR	Open; grass-sage
**Chestnut-collared longspur	-	B-SR	■

---

[1] Status Codes: M-migrant; SR-summer resident; WR-winter resident; YR-year-round resident; B-breeding bird; V-visitant (present for short time only); U-uncommon; C-common

[2] Banding Codes: no. = no. banded; NB-captured, not banded; E-escaped before banding. All banding on south site.

* south site

**both sites

Table 13. Checlist of birds (Con't)

SPECIES	No. Banded[2]	Status[1]	Preferred Habitat On/About AMAX Properties
*Belted kingfisher	-	U-V	Shallow water areas w/perches
**Common flicker	-	B-YR	Windrows w/tall trees (at 25')
*Red-headed woodpecker	-	C-V	Open areas w/cable poles, wood fence posts; trees
**Eastern kingbird	-	C-SR	Open areas w/perches around buildings
**Western kingbird	-	C-SR	"
**Say's phoebe	1	B-SR	"
*Willow flycatcher	1	U-SR	Dense shrubs 5-15'; windrows
**Horned lark	5	B-YR	Open areas - grass-sage
**Barn swallow	-	B-SR	Buildings; bluffs, bridges
**Cliff swallow	-	B-SR	Bluffs; bridges
**Common crow	-	U-YR	Varied; open areas
**Black-billed magpie	-	U-YR	Varied; windrows
*Black-capped chickadee	-	U-YR	Tall trees
*House wren	-	U-SR	Thick shrubs; windrows
**Rock wren	-	B-SR	Rock bluffs & buttes
**Brown thrasher	2	C-V	Open windrows; shrubs
*Gray catbird	-	U-SR	Thick shrubs; windrows
**American robin	3	U-YR	Buildings; windrows
*Hermit thrush	2	U-V	Thick shrubs, windrows
**Mountain bluebird	-	U-YR	Buildings; windrows
**Loggerhead shrike	4	B-SR	Open areas w/perches, open windrows; buildings
**Starling	-	C-YR	Varied; buildings; windrows
*Yellow warbler	3	U-SR	Thick, tall shrubs; windrows; trees; water areas
*American redstart	1	U-SR	"
*Common yellowthroat	1	B-SR	Tumbleweed areas near water; thick windrows
*Audubon's warbler	3	U-SR	Thick, tall shrubs, trees, windrows
*Chestnut-sided warbler	1(E)	U-V	"
**House sparrow	-	B-YR	Buildings; windrows
*Bobolink	-	U-V	Open areas near windrows
**Western meadowlark	6	B-SR	Open, sage-grass w/perches
**Red-winged blackbird	2	B-SR	Open, sage-grass water marsh areas
**Yellow-headed blackbird	-	U-SR	"
**Brewer's blackbird	1	B-SR	"
**Common grackle	-	C-SR	Varied; windrows
**Brown-headed cowbird	-	C-SR	"
*Northern (Bullock's) oriole	1(E)	U-V	Thick, tall shrubs, trees, windrows

Table 13. Checklist of birds observed on AMAX properties near Gillette, Wyoming.

SPECIES	No. Banded[2]	Status[1]	Preferred Habitat On/About AMAX Properties
*Pied-billed grebe	-	U-SR	Shallow lakes
*Horned grebe	-	M	"
*Eared grebe	-	U-SR	"
**Great Blue Heron	-	U-SR	Shallow water areas
**Canada goose	-	M	Shallow lakes
**Mallard	-	B-SR	Shallow water areas
**Pintail	-	B-SR	"
**American wigeon	-	B-SR	"
**Gadwall	-	B-SR	"
**Shoveler	-	B-SR	"
**Green-winged teal	-	B-SR	"
**Killdeer & blue-winged teal	-	B-SR	"
**Cinnamon teal	-	B-SR	"
**Lesser scaup	-	M	Shallow lakes
**Redhead	-	M	"
**Ring-necked duck	-	M	"
**Common goldeneye	-	M	"
**Bufflehead	-	M	"
**Ruddy duck	-	U-SR	"
**Golden eagle	-	B-YR	Varied-open sage-grass
**Bald eagle	-	C-WR	"
**American rough-legged hawk	-	C-WR	"
**Red-tailed hawk	-	B-SR	"
**Ferruginous hawk	-	U-YR	"
**Marsh hawk	-	B-SR	Sage-grass; water areas
**American kestrel	-	B-SR	Sage-grass; tall trees
**Sage grouse	-	B-YR	Sage-grass
**Gray partridge	-	B-YR	Grass-open windrow-wheat
**American coot	-	B-SR	Shallow water areas
*Killdeer	-	B-SR	Grass-open areas near water
**Spotted sandpiper	-	B-SR	Shallow water areas
*Baird's sandpiper	-	M	"
*Long-billed curlew	-	U-V	Shallow lake mudflats
*Long-billed dowitcher	-	M	Shallow lake shallows
**Wilson's phalarope	-	C-SR	"
*Northern phalarope	-	U-M	"
*California gull	-	U-V	Shallow lake
*Herring gull	-	U-V	"
*Black tern	-	U-V	"
**Rock dove	-	YR	Buildings; bridges
**Mourning dove	10(NB)	B-SR	Open grass-sage, windrows
**Great horned owl	-	B-YR	Varied; sage-grass; windrows

Table 12. Lagomorph night-light road census data.
North and south Gillette site.
Density index expressed per linear mile.

South Site

Date	Route Miles	Jackrabbits No.	Jackrabbits Per Mile	Cottontails No.	Cottontails Per Mile	Total lagomorphs/ Mile
1/9/74	10.9	12	1.1	1	0.1	1.2
1/15/74	6.3	-	-	10	1.6	1.6
1/25/74	11.9	40	3.4	2	0.2	3.5
2/14/74	9.1	25	2.7	3	0.3	3.1
2/28/74	16.0	15	0.9	2	0.1	1.1
3/7/74	10.0	74	7.4	8	0.8	8.2
3/14/74	18.0	26	1.4	3	0.1	1.6
4/18/74	9.4	27	2.9	14	1.5	4.4
5/20/74	10.0	23	2.3	5	0.5	2.8
Totals	101.6	242	2.4	48	0.5	2.9

North Site

Date	Route Miles	Jackrabbits No.	Jackrabbits Per Mile	Cottontails No.	Cottontails Per Mile	Total lagomorphs/ Mile
3/15/74	7.5	3	0.4	1	0.1	0.5
5/23/74	7.5	1	0.1	1	0.1	0.3
6/3/74	7.5	-	-	1	0.1	0.1
Totals	22.5	4	0.2	3	0.1	0.3

Type & Name of Public School	Grade Levels	Current Enrollments	Maximum Enrollment Capacity	% of Max. Enrollment Capacity	School Site Acreage	Structural Type
ELEMENTARY						
1. Hillcrest	1-6	293	350	83.7	6-7	Permanent, built in 1971
2. Northside	K-6	307	350	87.7	3	Permanent, built in 1971
3. Stocktrail	4-6	242	350	69.1	9	Permanent, built in 1971
4. Westside	1-3	226	225	100.4	2	Octogon & mobile module units
5. Eastside*	K-6	332	350	94.7	-	Temporary, mobile trailers
SUBTOTAL		1,400	1,625	86.2		
JUNIOR HIGH						
1. Campbell County**	7-9	699	650	107.5	12	7 separate buildings
SENIOR HIGH						
1. Campbell County***	10-12	601	1,100	54.6	40	Permanent, built in 1972
TOTALS		2,700	3,375	80.0		

*Will be replaced by new 350 student capacity elementary school on 3-acre site in Fall 1975.

**New junior high facilities to be completed by Fall 1975 and with facilities at the old high school will accommodate a maximum enrollment of 1,100 pupils.

***Existing facility can be expanded to accommodate an additional 400 students.

Source: Mr. J.O. Reed, School Superintendent, Campbell County Unified School District, March 22, 1974.

Table 56

Public Schools in Gillette, Campbell County
1974

Name of School	Grade Levels	Current Enrollment	Maximum Enrollment Capacity	% of Max. Enrollment Capacity	Structural Type
Alcott	K-8	43	55	78.2	2-room frame bldg; metal bldg; mobile trailer
Bates Creek	K-8	2	10	20.0	Mobile trailer unit
Bundy	K-8	15	24	62.5	Old, 2-room frame, permanent building
Cactus	K-8	5	11	45.5	Mobile home trailer
Gap	K-8	19	15	126.7	2-room, wood frame building
Highway	K-8	15	25	60.0	2-room, wood frame building
Little Powder	K-8	26	30	86.7	2-room, wood frame building
Rawhide	K-8	26	30	86.7	Mobile trailer unit
Rimrock	K-7	1	6	16.7	Mobile trailer unit
Recluse	K-8	65	80	81.3	Excellent 6-room, wood frame building
Rozet	K-8	74	80	92.5	Excellent, 6-room building, plus a gymnasium
Teckla	K-8	2	6	33.3	Mobile trailer unit
Savageton	K-8	13	22	59.1	Mobile trailer unit
Wyodak	K-4	16	22	72.7	Temporarily closed, remodeling 2-room building
TOTALS		322	416	77.4	

Source: Mr. J. O. Reed, School Superintendent, Campbell County Unified School District, March 22, 1974.

Table 57

Rural Public Schools of Campbell County
1974

	Campbell	Converse	Crook	Johnson	Natrona	Niobrara	Sheridan	Weston	Region	Wyoming
Physicians	7	4	1	4	67	1	25	3	112	363
Dentists	3	2	1	2	27	1	12	1	49	157
R.N.'s	30	24	15	17	298	10	118	20	532	1,559
L.P.N.'s	13	5	0	8	123	3	26	8	186	440
School Nurses	5	2	1	1	10	0	2	0	21	54
P.H.N.'s	2	0	0	0	5	0	2	0	9	40
Pharmacists	7	5	1	8	39	1	25	4	90	287
Optometrists	2	1	0	½	6	1	1½	1	13	41½
Dental Hygienists	2	0	0	0	7	0	5	0	14	25
Sanitarians	1 (1)*	*	*	*	1(2)	*	*	*	5	14

*Covered by District #3 (Gillette)
(-) Apprentices

Source: Wyoming Department of Health and Social Services, Comprehensive Health Planning, Wyoming Health Profiles 1972.

Table 60

Health Manpower
Powder River Basin

Table 61

Existing and Recommended Health Manpower - Population Ratios

	Campbell	Converse	Crook	Johnson	Natrona	Niobrara	Sheridan	Weston	Wyoming	Recommended Ratios
Population (1970)	12,957	5,938	4,535	5,587	51,264	2,924	17,852	6,307	332,416	
Population Ratios*	**									
Physicians	1,851	1,485	4,535	1,396	765	2,924	714	2,102	916	1,000
Dentists	4,319	2,969	4,535	2,794	1,899	2,924	1,488	6,307	2,117	1,600
R.N.'s	432	247	302	329	172	292	151	315	213	285
L.P.N.'s	997	1,188	---	698	417	975	687	788	755	614
Optometrists	6,479	5,939	---	11,174	8,544	---	11,901	6,307	8,010	7,000
Sanitarians***	13,518	---	---	---	---	---	5,951	---	23,744	12,000
Pharmacists	1,851	1,188	4,535	698	1,314	2,924	714	1,577	1,158	N.A.
School Nurses	2,591	2,969	4,535	5,587	5,126	---	8,926	---	6,156	N.A.
P.H.N.'s	6,479	---	---	---	10,252	---	8,926	---	8,310	N.A.
Dental Hygienists	6,479	---	---	---	7,323	---	3,570	---	13,297	N.A.

*Population Ratio = number of persons per physician, dentist, R.N., etc.
**Population for District #3, aggregated over 7 counties = 27,035.
***Ratio includes apprentice sanitarians.

Source: Wyoming Department of Health and Social Services, Comprehensive Health Planning, Wyoming Health Profiles 1972.

Table 62

Health Facility Utilization and Need (1970)

General Hospitals	Campbell	Converse	Crook	Johnson	Natrona	Niobrara	Sheridan	Weston	Region	Wyoming
Number Beds	31	32	16	26	298	24	89	42	495	1,693
Patient Days (1971)	6,468	4,218	1,432	6,366	79,375	3,639	20,087	7,478	141,181	363,030
Utilization Rate*	779	1,029	477	1,273	1,407	2,022	1,225	971	1,148	1,092
Bed Need	31	24	15	31	267	22	75	35	500	1,413
Bed Shortage	--	--	--	5	--	--	--	--	--	--
Bed Excess	--	8	1	--	31	2	14	7	58	280
Extended Care Facilities										
Number Beds	125	59	0	40	195	0	96	42	557	1,412
Patient Days	35,980	19,911	--	10,277	63,139	--	29,971	10,125	169,403	439,146
Utilization Rate***	43,349	31,307		14,536	14,445		9,282	18,785	16,463	13,211
Bed Need	123	73	17**	42	208	24**	122	42	651	1,815
Bed Shortage	--	14	17	2	13	24	26	--	94	403
Bed Excess	2	--	--	--	--	--	--	--	--	--

*1971 Patient days per 1000 population
**Projected by Wyoming Department of Health and Social Services
***Patient days on population 65 or over
Source: Wyoming Department of Health and Social Services, Wyoming Medical Facilities Planning and Construction. Bed need estimates based on Hill-Burton and Hill-Harris formula.

Table 63

Sheriff's Department
Powder River Basin Region
1972-1973

County	Total Population*	Sworn Officials		Civilian Staff		Full-Time Sworn Officer Per 1,000 Population	Population Served Per Full-Time Officer	Land Coverage Per Full-Time Officer (Sq. Miles)
		Full-Time	Part-Time	Full-Time	Part-Time			
Campbell	12,957	5	-	3	1	0.38	2,591	951
Converse	5,938	4	-	2	-	0.67	1,484	1,070
Crook	4,535	4	2	1	-	0.88	1,134	720
Johnson	5,587	2	1	1	3	0.35	2,793	2,087
Natrona	51,264	30	-	7	-	0.58	1,708	178
Niobrara	2,924	2	-	-	-	0.68	1,462	1,307
Sheridan	17,852	4	-	-	-	0.22	4,463	633
Weston	6,307	2	2	2	-	0.31	3,153	1,203

*1970 Census of Population.

Source: State of Wyoming Governor's Planning Committee on Criminal Administration, (Criminal Justice System Data Book - 1972), State of Wyoming (January 1974). Cheyenne (January 1974).

Table 64

Municipal Police Departments
Powder River Basin Region
1972-1973

City/Town	County	City/Town Population*	Sworn Officials Full-Time	Sworn Officials Part-Time	Civilian Staff Full-Time	Civilian Staff Part-Time	Number of Full-Time Officers Per 1,000 Population	Number of People Served Per Full-Time Officer
Gillette	Campbell	7,194	16	1	6	-	2.22	450
Douglas	Converse	2,677	6	-	4	-	2.24	446
Glenrock	Converse	1,515	5	-	-	-	3.30	303
Sundance	Crook	1,056	1	6	-	-	0.94	1,056
Buffalo	Johnson	3,395	6	-	-	1	1.76	566
Casper	Natrona	39,361	56	-	17	-	1.42	703
Mills	Natrona	1,724	2	-	-	-	1.16	862
Lusk	Niobrara	1,495	4	-	-	-	2.67	374
Sheridan	Sheridan	10,856	17	1	6	-	1.56	638
Newcastle	Weston	3,432	9	-	4	1	2.62	381
Wyoming							1.64	610
United States							1.47	680

*1970 Census of Population

Source: Criminal Justice System Data Book - 1972, Governor's Planning Committee on Criminal Administration, State of Wyoming, January 1974.

Table 70

Public Attitudes Regarding Improvements Needed in Campbell County, by Employment of Respondent

Improvements	Percent Responding	
	Mineral-Related Employment	Ranching
More entertainment, recreational activities	38%	22%
Retail stores	34%	14%
Better streets and roads	30%	16%
Medical facilities and services	19%	19%
More quality housing	15%	---
Updated local administration	11%	---
Fire, police, transportation and other public services	8%	---
Nothing	---	11%
No more new people; no new town	---	10%

Source: Denver Research Institute, Socio-Economic Impacts of Proposed Burlington Northern and Chicago North Western Rail Line in Campbell-Converse Counties, Wyoming, (March 1974).

Table 71

Public Attitudes Regarding Changes Necessary to Accommodate Rapid Population Growth
Campbell County, Wyoming

Change Description	Percent Responding	Rank
More housing, lower cost housing, better quality housing.	60%	1
More retail stores, businesses and shopping centers to add variety and availability through competition.	32%	2
Better water and sewer treatment facilities.	22%	3
More schools and teachers.	19%	4
More and better medical facilities (including hospitals); more doctors (including specialists).	16%	5
Planned housing developments with open space and recreation facilities; more better planned mobile home parks with better public facilities, open space, and recreation.	15%	6
More attention to zoning by local government; better planning for housing, education, recreation, public services, and growth policy.	14%	7
More fire and police protection; better transportation systems (including within Gillette as well as for the rural population); better trash collection, snow removal, power, utilities (especially in rural Campbell County).	9%	8
More updated local elected officials; more democratic distribution of power at local level; more efficient administration --Gillette government cannot handle this magnitude of problem.	8%	9
More variety of amusement, entertainment, cultural and recreational activities; this included indoor activities such as bowling, movies, restaurants, and outdoor activities such as parks, tennis courts, swimming facilities, etc.). It was originally broken into activities for adults, activities for the elderly, and activities for young people.	8%	10

Sample size: n=474

Source: Denver Research Institute, Socio-Economic Impacts of Proposed Burlington Northern and Chicago North Western Rail Line in Campbell-Converse Counties, Wyoming, (March 1974).